Intensive care unit organisation and its impact on patient and nurse outcomes: a cross-sectional study of two models

The 'hot-floor' study

Brett John Abbenbroek

RN, ICU cert., Management cert., BSc, MPH

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

University of Technology Sydney

Faculty of Health

March 2018

CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Production Note:
Signature of Candidate: Signature removed prior to publication.

16th March 2018

This research is supported by an Australian Government Research Training Program Scholarship.

ACKNOWLEDGMENTS

My experience as a Nurse Manager grappling with the challenges of a new intensive care hot-floor service instigated this PhD. Patient activity and complexity was steadily growing and I was responsible for 300 clinical staff. I searched for guidance to meet these challenges but found very little. I decided to explore how organisational characteristics of the hot-floor impacted on patients and staff with the view of informing better health service management.

The road to completion has been long, difficult and convoluted but I have grown personally and intellectually. I have never been strong academically but I am tenacious and organised, both essential to realising this professional goal. If it were not for my supervisors' guidance, teaching and perseverance in raising my academic rigour I would not have succeeded. I have learnt so much on this journey, thank you.

So many people to acknowledge, thank you to everyone for your support. The following people need special mention. Professor Malcolm Fisher and Professor Paul Torzillo supported my initial application to undertake this study, and I truly appreciate your faith in me. My principal supervisor Professor Christine Duffield challenged me to explore and enquire while pulling me out of the many rabbit holes I went down in search of answers. Thank you Christine for keeping me focussed and inspiring me to push forward. Professor Doug Elliott steered me with a steady hand towards becoming a researcher and to improve my academic literacy. Thank you Doug for your clarity, insights and ingenuity for conceptualising ideas. Together my supervisors were a formidable team and I can't express my appreciation enough for their support.

Working and studying is always challenging let alone balancing these with your personal life. My partner Wayne Parcell inspired me with his 'can do' approach to life and supported me by being my sounding board and voice of reason. To my parents Rhonda and Alan, thank you for your loving support and nourishment. Mum you are an inspirational person and I could not have done this without your love and encouragement.

Lastly, midway on this journey I was reminded how lucky I am to have had this opportunity by a fortune cookie that read *'Learning is a treasure that will follow its owner everywhere'.*

This PhD is dedicated in memory to my friend and colleague Therese Clarke (5.2.1962 – 3.10.2001).

Thank you.

TABLE OF CONTENTS

CERTIFICATE OF ORIGINAL AUTHORSHIP I
ACKNOWLEDGMENTS II
TABLE OF CONTENTS III
LIST OF TABLES VI
LIST OF FIGURES VII
PEER REVIEWED PUBLICATIONS AND PRESENTATIONS VIII
ABSTRACT IX
1 INTRODUCTION 1
1.1 The intensive care unit 3
1.2 Increasing demand, building capacity and costs 5
1.3 Study purpose and significance 9
1.4 Research questions 10
1.5 Thesis organisation 10
2 ORGANISATION, PROCESS, WORKFORCE AND QUALITY 12
2.1 ICU organisation and model of care 13
2.2 Operational management and care processes 19
2.3 Workforce 21
2.4 Quality management 28
2.5 Conceptual framework 30
2.6 Summary 33
3 LITERATURE REVIEW OF ICU ORGANISATIONAL OUTCOMES 34
3.1 Introduction 34
3.2 Patient outcomes and unit level measures 37
3.2.1 Integrative review of patient and unit measures 37
3.2.2 ICU quality management reviews 39
3.2.3 Integrative review of empirical outcome studies 44
3.2.4 Patient outcomes 47
3.2.4.1 Unplanned extubation 47
3.2.4.2 Ventilator associated pneumonia 49
3.2.4.3 Central line associated bloodstream infection 50
3.2.4.4 Venous thrombosis embolism 52
3.2.4.5 Catheter associated urinary tract infection 53
3.2.4.6 Pressure injury 53
3.2.4.7 Falls 54
3.2.5 Unit level measures 55
3.2.5.1 Access 55
3.2.5.2 Length of stay 56
3.2.5.3 Unit occupancy 57
3.2.5.4 Annual patient volume 58
3.2.5.5 After-hours discharge 58
3.2.5.6 Discharge delay (exit block) 59
3.2.5.7 Unplanned readmissions to ICU 60
3.2.6 Interim patient outcome and unit level variables 61
3.2.7 Variable congruence with the clinical environment 62
3.3 Nurse outcomes 63
3.3.1 Literature review of nurse outcome measures 65
3.3.2 Quality appraisal 66

3.4 Nurse work environment survey instruments ... 74
3.5 Summary ... 76
4 METHODS ... 77
4.1 Introduction ... 77
4.2 Aim ... 77
4.3 Design ... 77
4.4 Study settings ... 79
4.5 Patient outcomes study procedures ... 79
4.5.1 Sampling ... 80
4.5.2 Data Collection ... 81
4.6 Nurse outcomes study procedures ... 83
4.6.1 Sampling ... 83
4.6.2 Data collection ... 84
4.6.3 Instrumentation ... 86
4.7 Data Management ... 91
4.8 Data analysis ... 93
4.9 Ethical considerations ... 96
5 RESULTS ... 97
5.1 Introduction ... 97
5.2 ICU hot-floor and conventional ICU settings ... 97
5.2.1 Structure, Process and Casemix ... 97
5.3 Workforce ... 100
5.4 Patients ... 101
5.4.1 Demographic and clinical characteristics ... 101
5.4.2 Patient outcomes ... 103
5.5 Nursing staff ... 104
5.5.1 Demographic and work characteristics ... 104
5.5.2 Nurse outcomes ... 107
5.5.3 Outcome and work environment associations ... 113
6 DISCUSSION ... 119
6.1 Introduction ... 119
6.2 Hot-floor model organisational reliability ... 121
6.3 Maintaining a healthy ICU work environment ... 126
6.4 Protecting high risk patients through standardisation ... 133
6.5 Human resourcing for high organisational reliability ... 135
6.6 Strengths and limitations ... 138
6.7 Implications for practice, policy and management ... 141
6.8 Future research ... 144
6.9 Conclusion ... 147
REFERENCES ... 149
APPENDICES ... 196
1. Manuscript ICU Volume – Mortality 2014 ... 196
2. Quality management review studies ... 204
3. ICU outcomes and unit level measures ... 209
4. Nurse outcome definitions ... 226
5. Manuscript – ICU nurse survey instrument ... 229
6. Survey instruments ... 249
7. Participant information sheet ... 252

8. Survey Monkey link correspondence ... 254
9. ICU nurse survey instrument ... 255
10. Data management planning checklist ... 263
11. SPSS codebook ... 264
12. Aggregated work and demographic variables ... 266
13. Patient sample distribution ... 267
14. Patient sample distribution test results ... 270
15. Patient data transformation and distribution ... 272
16. ICU service characteristics ... 273
17. ICU workforce structures ... 274
18. ICU workforce snapshot May 2014 ... 275
19. Workforce stability ... 276
20. Patient sample correlation analysis ... 279
21. Model for within nurse groups analysis ... 280
22. Results for within groups Pearson's Chi-square analysis ... 281
23. Principal component analysis ... 283
24. PES-NWI principal component analysis scree plot ... 285
25. Subscale factor loadings ... 286
26. Varimax rotation subscale factor loadings ... 288
27. Confirmatory factor analysis ... 289
28. Nurse sample distribution plots ... 291
29. Nurse sample distribution test results ... 295
30. PES-NWI and MBI correlation coefficients ... 298
31. PES-NWI and MBI subscale correlation coefficients and z-scores ... 299
32. Critical Mahalanobis distance values ... 300
33. Multivariate MANOVA[1] results ... 301
34. Two-way ANOVA PES-NWI and MBI ... 311

LIST OF TABLES

1.1	Thesis structure	11
2.1	ICU organisational and structural characteristics	15
2.2	ICU operational management and clinical processes	19
2.3	University Hospital of Berne: ICU Patient Data from 1998 to 2003	21
2.4	ICU workforce characteristics	24
3.1	Patient and unit level outcome measures identified for empirical analysis	44
3.2	Literature search summary of ICU quality management empirical studies	45
3.3	Patient and unit variables identified through stage one and stage two	62
3.4	Congruence of patient and unit level variables	63
3.5	Derived quality index of nurse outcome studies	68
3.6	Derived quality index definitions	69
3.7	Risk of bias appraisal of nurse outcome studies	71
3.8	Relative risk of bias for all nurse outcome studies	72
3.9	Nurse outcome measures minimum dataset	73
3.10	Survey instrument reliability	74
3.11	Survey instrument congruence with nurse outcomes	75
4.1	Study setting selection criteria	80
4.2	Patient outcomes and unit level measures	81
4.3	ICU Nurse Survey Section C: PES-NWI	87
4.4	ICU Nurse Survey Section D: MBI-HSS	89
4.5	MBI subscale categorisation per normative sample scores	90
4.6	MBI normative mean subscale scores	90
4.7	Patient and nurse sample data audit steps	92
5.1	Unit capacities, activity and mortality	98
5.2	Patient admissions	99
5.3	Patient casemix	100
5.4	Patient sample characteristics	102
5.5	Patient outcomes results	103
5.6	Nurse demographic characteristics	105
5.7	Nurse work factors	106
5.8	Work perceptions	108
5.9	PES-NWI subscale scores	109
5.10	MBI subscale categorisation	110
5.11	MBI subscale results	111
5.12	Cronbach’s alpha scores	111
5.13	Comparison of mean scores for PES-NWI and MBI subscales	115
5.14	Significant results following MANOVA	116
6.1	Proposed workforce scenario for a four pod hot-floor model in Australia	143

LIST OF FIGURES

1.1	International ratios of ICU beds to 100,000 adult population	5
1.2	Australian ICU bed days 1996 - 2007 and population adjusted projections to 2030	6
1.3	Time series projections for NSW ICU/HDU bed utilisation to 2016	7
2.1	Key milestones in the evolution of ICU as a clinical specialty	12
2.2	ICU as a central clinical support service	13
2.3	Traditional ICU conceptual model	16
2.4	ICU 'hot-floor' conceptual model	16
2.5	Relationship between labour costs and number of ICU beds	23
2.6	Donabedian quality framework	30
2.7	Interrelationships of organisational factors with nurse and patient outcomes	31
2.8	Patient care delivery model	32
2.9	Conceptual framework	32
3.1	Organisational characteristics of the hot-floor model	34
3.2	Integrative review stages for patient and unit level variables	38
3.3	Quality management reviews search summary flow chart	40
3.4	International distribution of quality management review studies	41
3.5	Frequency quality indicators were recommended in ICU quality reviews	42
3.6	Quality indicator frequency (lowest to highest)	46
3.7	Integrative review stages for nurse outcomes	65
3.8	Quality appraisal flow diagram	67
4.1	Research approach	78
4.2	Patient data collection process	82
4.3	Flow diagram summarising steps taken for data preparation and analysis	93
5.1	Patient age distributions	105
5.2	MBI subscales score frequencies	110

PEER REVIEWED PUBLICATIONS AND PRESENTATIONS

Peer reviewed publications:

Abbenbroek, B., Duffield, C.M. & Elliott, D. 2014, 'The intensive care unit volume–mortality relationship, is bigger better? An integrative literature review. *Australian Critical Care*, vol. 27, no. 4, pp. 157-64.

Abbenbroek, B., Duffield, C. & Elliott, D. 2014, 'Selection of an instrument to evaluate the organizational environment of nurses working in intensive care: an integrative review', *Journal of Hospital Administration*, vol. 3, no. 6, pp. 143-62.

Abbenbroek, B., Duffield, C. & Elliott, D. 2017, 'Intensive care unit organisation and nurse outcomes: A cross-sectional study of traditional and "hot-floor" structures', *Journal of Hospital Administration*, vol. 6, no. 3, pp. 67-76.

Conference presentations:

Abbenbroek, B. Evaluating the impact of the intensive care 'hot-floor' model. 5th International Conference on Safety, Audit, Quality and Outcomes Research in Intensive Care, Hunter Valley, Australia, August 2011.

Abbenbroek, B., Duffield, C., & Elliott, D. Intensive care unit volume-outcome relationship: Is bigger better? ANZICS/ACCCN 36th Intensive Care Annual Scientific Meeting, Brisbane Australia, October 2011.

Abbenbroek, B., Duffield, C., & Elliott, D. Intensive care unit volume-outcome relationship: Is bigger better? 11th Congress of the World Federation of Societies of Intensive and Critical Care Medicine, Durban South Africa, September 2013 (Poster).

Abbenbroek, B., Duffield, C., & Elliott, D. Selection of an instrument to evaluate the organizational environment of nurses working in intensive care: an integrative 12th Congress of the World Federation of Societies of Intensive and Critical Care Medicine, Seoul South Korea, September 2015 (Poster).

ABSTRACT

Aim: To explore the organisational effectiveness and impact on patient and nurse outcomes of two alternative closed Intensive Care Unit (ICU) models in Australia.

Background: Internationally the demand for critical care is increasing. Solely increasing bed capacity is not feasible due to high resource requirements and burgeoning costs. Consolidation of conventional 'stand-alone' ICUs into large multi-specialty integrated service models, the ICU 'hot-floor', is a preferred organisational strategy. Assumed benefits include improved patient throughput and resource utilisation, concentrated expertise and enhanced operational flexibility. The effect on patient and nurse outcomes however, is not well understood. Balancing efficiency and effectiveness is fundamental to high organisational reliability and sustainability.

Design and method: This study compared a general ICU within a hot-floor service and a conventional general ICU with similar service level and workforce characteristics. Patient throughput measures and outcomes were retrospectively investigated in a sample of 1000 randomly selected patient records during 2013. In 2014, a sample of 145 clinical nurses, split between both units, completed a structured questionnaire that incorporated validated instruments to examine the work environment, satisfaction and burnout.

Outcome measures: Patient mortality, unplanned extubation, catheter associated blood stream infections, pressure injury, venous thrombosis prophylaxis, length of stay, after-hours discharge and unplanned readmission, and unit level access, occupancy and volume were collected. The Practice Environment Scale-Nursing Work Index and Maslach's Burnout Inventory, along with supplementary questions on work perceptions, were used to collect nurse outcomes.

Results: The hot-floor model achieved higher patient throughput and a lower after-hours discharge rate, with no significant differences in patient outcomes. Patients were however more exposed to the risk of an adverse event such as deep vein thrombosis due to lower compliance with routine clinical prophylaxis protocols. Front-line nursing management, education, clinical support and senior medical staff were shared across the hot-floor service, resulting in less dedicated resources allocated to the general ICU. Nurse manager support was less effective and nurses expressed lower personal accomplishment. High patient turnover and paid overtime compounded nurse workload, though greater internal hot-floor operational flexibility reduced nurse redeployment to external wards.

Conclusion: Improved demand management achieved through greater operational flexibility is a key driver for the hot-floor model. Efficiency gains need to account for the work environment to optimise nurse outcomes, reduce turnover and mitigate patient risks. Adequately resourced front-line nursing management and education are required for high organisational reliability and long-term sustainability.

Keywords: Burnout, intensive care, nurse, organisation, outcome, patient, practice environment

1 INTRODUCTION

Intensive care services are essential to today's acute care hospital (Vincent & Creteur 2017), enabling critically ill patients to be managed in a dedicated area with high resource inputs and staff ratios, and sophisticated medical technologies. Critically ill patients require timely access to the Intensive Care Unit (ICU) either onsite, within the treating hospital, or by referral across health service networks to achieve the best possible patient outcomes (Flabouris, Hart & Nicholls 2013; Skinner, Warrillow & Denehy 2015).

Internationally, demand for intensive care is growing due to aging populations, higher inpatient acuity with multiple co-morbidities and advanced medical technologies (Vincent 2017; Wallace, Seymour & Kahn 2017). Health services planning that increases bed capacity alone is not sustainable in terms of fiscal and human resources (Guidet, van der Voort & Csomos 2017; Rhodes, Moreno & Chiche 2011). Organisational strategies are therefore required to effectively manage increasing demand while constraining associated costs (Strauch et al. 2015). Enhancing flexibility and utilisation of the available bed capacity, while optimising patient and staff outcomes, is a primary organisational goal (Bai et al. 2016; Iapichino et al. 2007; Stone et al. 2006). Organisational changes in ICU, more than single therapies, have been demonstrated to significantly improve patient outcomes (Miele & Checkley 2016; Sasabuchi et al. 2015; van der Sluijs et al. 2017).

Structurally, ICUs are organised either as 'open' or 'closed' models for medical management of patient care. In the open model, patients are admitted under the care of their admitting specialist team, with an Intensivist (ICU trained specialist medical practitioner) available for consultation as needed, while in the closed model, admissions and clinical care is controlled by the Intensivist with specialist teams consulted as necessary (Sakr et al. 2015). Internationally, the closed model is predominant in Australia, New Zealand, Europe, the United Kingdom, South America and South Africa (Hyzy et al. 2010; Wilcox et al. 2014), in 85% of Canadian ICUs (Holodinsky et al. 2015) and 63% in Asia (Arabi et al. 2016). Compelling evidence supports the benefits of the closed model in relation to staff satisfaction and clinical outcomes (Gasperino 2011; Parikh et al. 2012; Vincent 2017). Benefits of the closed model include strict admission criteria ensuring only appropriate patients are admitted improving bed utilisation, holistic coordination of patient care (Hobson & Bihorac 2015; van der Sluijs et al. 2017) and creation of a healthy work environment (Katz et al. 2017). The closed model therefore also constrains bed growth and burgeoning costs due to evidence based criteria for patient triage and admission (van der Sluis et al. 2011). In contrast, the open model is operated primarily in the United States (US) (Hyzy et al. 2010; Skinner, Warrillow & Denehy 2015), although the closed model is increasingly being adopted.

While the organisational effectiveness of the closed model is reflected by improved patient outcomes, increasingly the model in the traditional 'stand-alone' configuration, is struggling to efficiently manage growing demand for intensive care (Aslanidis 2015). In response, these separate stand-alone ICUs within single hospitals and across hospital networks are being reorganised into large critical care services (Meadows, Rattenberry & Waldmann 2011; Wallace, Seymour & Kahn 2017). As a result, the dominance of the closed model over the past five decades is giving way to a hybrid closed-open model where a combination of closed and open beds are managed within one integrated critical care service. In Australia, this ICU 'hot-floor' model consists of multiple pods (units) of critical care sub-specialties, commonly neurosciences, cardiothoracic surgery, trauma, general surgery and medicine (AHIA 2014) collocated and managed as a single integrated service. Typically the hot-floor is a tertiary level service with high acuity, activity and technical complexity, and reflects the health services management trend toward integrated service models and resource consolidation (Piña et al. 2014; Rashid 2014b; Suntharalingam, Handy & Walsh 2014).

The aim of the hot-floor is to better balance efficient demand management and organisational effectiveness so as to achieve a high degree of organisational reliability. High Reliability Organisations (HROs) conduct operations with minimal error over an extended time in the quest for high quality and dependable reliability (Roberts 1990). Principles stemming from HRO theory are common to industries such as commercial aviation that require near error free high frequency performance (Ravitz & Pronovost 2015). Organisations take different approaches to achieve high reliability according to their operational context, activities and goals, and therefore the same approach cannot be directly applied between industries (Wasden 2017). Increasingly, HRO principles are being adopted in health service planning to promote patient safety and organisational effectiveness in healthcare, and are ideally suited to the high-risk environment of ICU (Christianson et al. 2011; Hartmann et al. 2013).

Health service planning in Australia is conducted in accordance with the Australasian Health Facility Guidelines (AusHFG) (AHIA 2014), which recommend the hot-floor integrated critical care service model for new or redeveloped ICUs. Despite this policy and planning requirement, it is not known if the hot-floor model can achieve the balance in organisational efficiency and effectiveness required to fulfill HRO principles and thereby provide a viable organisational solution for the provision of high quality critical care into the future.

This study aims to address this knowledge deficit. To establish the study context the ICU environment and the drivers of increasing demand for intensive care are described in this chapter. The significance of this area of inquiry for health services management is then outlined followed by the specific research questions to be answered. A summary of this thesis organisation follows to assist the reader to navigate the roadmap for this study of the ICU hot-floor model.

1.1 The intensive care unit

The ICU is an organisational intervention aimed at improving outcomes for patients who require continuous monitoring and simultaneous combinations of supportive therapeutic interventions, point of care diagnostics and clinical care (Costa & Kahn 2016; Patel, Kaufman & Cohen 2014). Patients who have actual or potential life-threatening illness or injuries are concentrated in a dedicated area of the hospital with high staffing ratios, highly skilled specialist trained staff, sophisticated medical technologies and high resource inputs (ANZICS CORE 2014a). The decision to admit a patient to ICU is based on a comprehensive clinical assessment, likely patient benefit, patient wishes if known and appropriate use of limited available resources (Capuzzo, Moreno & Alvisi 2010; Dicosmo 1999; Leung, Wong & Gomersall 2016).

Early studies on patient outcomes identified that efficient and effective intensive care teams are those that prioritise the organisation of skilled professionals rather than individual therapies or sophisticated technologies (Knaus et al. 1986). Optimal quality and safety require an appropriate environment for skilled clinical teams to deliver quality care 24 hours a day, 7 days a week. Specific guidelines for patient selection, staffing, structural requirements, support services, operational policies, physical design and equipment have been developed for traditional closed ICUs and are credited for the evolution of the ICU as a distinct organisational entity (Grenvik & Pinsky 2009). Despite these advances, staffing profiles in terms of quantity, experience and expertise remain a key determinant for quality of care and patient outcomes (Cho, Hwang & Kim 2008; Fink 2011; Neuraz et al. 2015). For example, 24-hour physician coverage across a 7-day week staffing model has been progressively established (Dimick et al. 2001; Fink 2011). An early systematic review of physician staffing patterns demonstrated a 10% median reduction in mortality, exceeding the impact of any known single clinical ICU intervention (Pronovost et al. 2002). The positive impact of 24-hour intensivist cover continues to be supported in contemporary literature with intensivist staff ratios and workload emerging as major factors for improved patient outcomes and staff satisfaction (Pastores 2015; Ward et al. 2013).

These findings are particularly relevant to the ICU hot-floor, which typically has a large bed capacity and high patient volumes. Medical and nurse staffing needs to keep pace with ICU size, bed capacity and increasing clinical complexity at the point of care (Ward & Howell 2015). In Australia, a staffing ratio in ICU of one nurse to one critically ill patient on a 24-hour basis is universally practised (Elliott, Aitken & Chaboyer 2011; McAdam & Puntillo 2015). High nurse to patient ratios have been repeatedly linked to positive outcomes in acute care settings (Aiken, Cimiotti, et al. 2012; Neuraz et al. 2015; West et al. 2014). Complementing the nurse:patient ratio is the nurse's broad scope of practice that includes coordinating and administering multiple simultaneous pharmacological regimens, adjusting ventilation in response to the patient's physiology, physical care and clinical prophylaxis, and psychological support (ACCCN 2016).

Evidence based clinical management is coordinated by a multidisciplinary team and is typically highly standardised based upon best practice. A medical intensivist leads the clinical team in collaboration with nursing, allied health and primary medical specialist teams. Front-line nursing management, education and dedicated allied health staff have been associated with a reduction in adverse drug events, decreased length of stay, ventilator days and overall ICU costs (Kucukarslan et al. 2013; Thomas et al. 2015). As the organisation of intensive care evolves through interventions such as the hot-floor model, proactive workforce planning is required for adequate resourcing to support a healthy work environment (AACN 2016), promote clinical quality and safety, and maximise potential organisational benefits to achieve high reliability (Aboumatar et al. 2017).

1.2 Increasing demand, building capacity and costs

Intensive care is one of fastest growing and most expensive healthcare disciplines (Crippen 2013). Demand for ICU beds regularly exceeds availability with rates of refusal of admission, due to unavailable resources, ranging from 18–42% (Leung, Wong & Gomersall 2016). By 2050, the global population is projected to increase from 7.2 billion to 9.6 billion, increasing the number of people who may need critical care and substantially presenting an enormous challenge for health services (Arabi, Schultz & Salluh 2016). Compounding population driven demand are new technologies to salvage patients with clinical conditions previously considered fatal (Victorian Government DHHS 2009; Vincent & Creteur 2017).

The subsequent growth in ICU beds, particularly in developed countries, has been significant (Zakhary, Turton & Ender 2016), though considerable variation in capacity is evident and primarily attributed to the organisational model (Murthy & Wunsch 2012). For example, in 2012 the open ICU model was prevalent in the US with bed capacity at 25 per 100,000 population (Wunsch, Gershengorn & Scales 2012) (see Figure 1.1). In stark contrast the United Kingdom (UK) is at 3.5 per 100,000 population with Australia also relatively low at 6.5 beds; both countries in which the closed model is ubiquitous (ANZICS CORE 2013b).

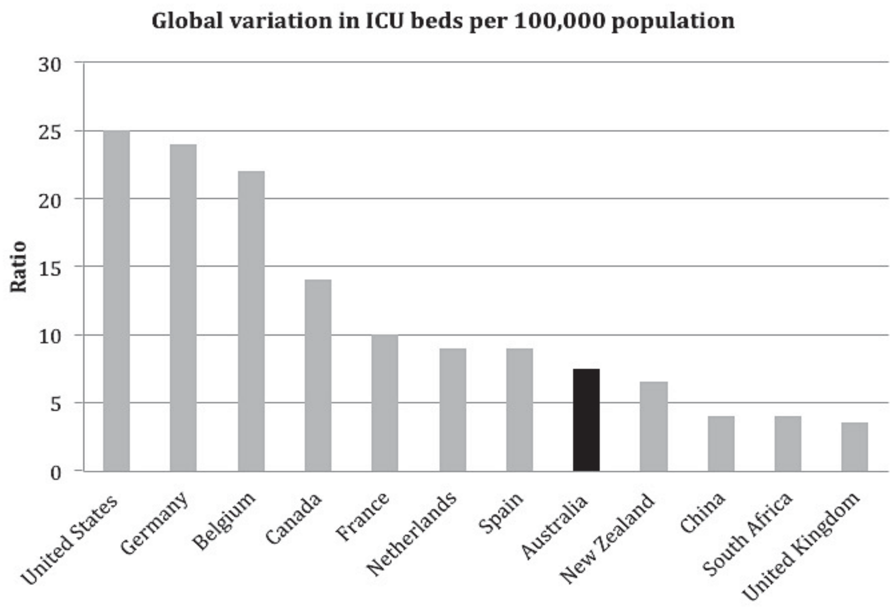


Figure 1.1 International ratios of ICU beds to 100,000 population

Source: (Murthy & Wunsch 2012) and (ANZICS CORE 2013b)

While the Australian bed capacity is relatively low, high quality service delivery is indicated by a low median Standardised Mortality Ratio (SMR) of 0.74 (ANZICS CORE 2014a). This is further supported by a low refusal rate of 2.2% (ACHS 2014) for patients otherwise suitable for admission, suggesting effective management of demand within the available bed capacity. However, demand for intensive care in Australia between 2010 and 2030 is predicted to increase by 46% (Corke et al. 2009) with a corresponding growth from 520,000 to 920,000 ICU bed days for the same period (see Figure 1.2) highlighting the need for organisational strategies that improve efficiency.

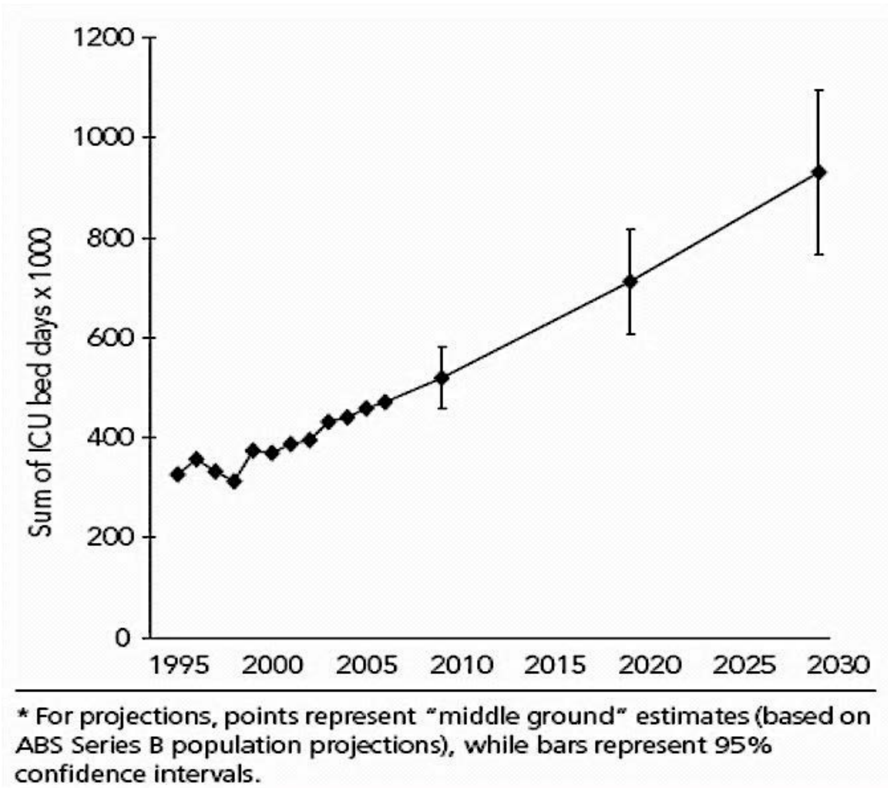


Figure 1.2 Australian ICU bed days 1996 - 2007 and population adjusted projections to 2030

Source: (Corke et al. 2009) pp. 259

Predictions have been confirmed by modelling for the state of NSW that is the local context for this study. Between 2010 and 2016 acute inpatient modelling projected annual growth at 2.5% (NSW Health 2010b) (see Figure 1.3), resulting in a total growth in demand for intensive care services of 17.5%.

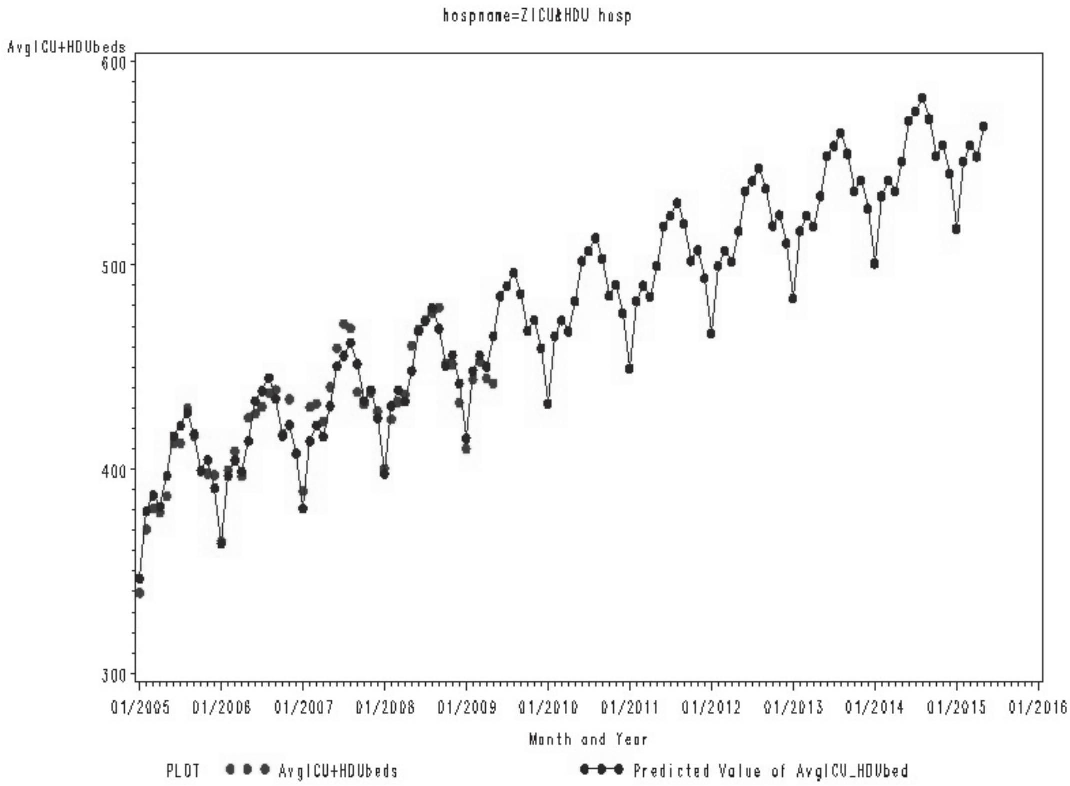


Figure 1.3 Time series projections for NSW ICU bed utilisation to 2016

Source: (NSW Ministry of Health 2010)

When extrapolated to 2030 a further 33% increase is projected resulting in a total growth in ICU bed days of 50% between 2010 and 2030. Based on this modelling and applying the NSW ICU bed per day cost estimate of $3,800 (NSW Health 2010a), an additional $117m of funding was allocated between 2010 to 2016, resulting in a total ICU funding allocation of $762m in 2016 or 4% of the corresponding year's state health budget. If growth continues according to NSW projections, ICU funding allocation would double to 10% of the total state health budget by 2030 (NSW Health 2017). Continued growth of this magnitude is not sustainable and skilled workforce shortages suggest the projected growth to 2030 is not feasible, a concern voiced by critical care clinical leaders globally (Einav, O'Connor & Chavez 2016; Matlakala, Bezuidenhout & Botha 2014a; Talib & Rahman 2015). The associated costs are a strong driver for considering innovative models of care and alternative organisation structures (Schreiter & Saeger 2011) which has resulted in the policy response to consolidate, or regionalise, standalone ICUs (Bennett 2015).

It has long been recognised that maintaining the same level of ICU resourcing and staffing across multiple hospitals with differing levels of intensive care complexity is not sustainable, requiring a tiered networked approach to service provision (Luft, Bunker & Enthoven 1979). The consolidation of beds into large regional ICUs (Wallace, Seymour & Kahn 2017) has occurred since the early nineties (Thompson et al. 1994) to better match patient severity with available resources and expertise (Nguyen, Wunsch & Angus 2010a). Lower complexity hospitals refer the sickest patients via defined clinical networks to regional ICUs for definitive care to manage demand for ICU beds (Amaral & Cuthbertson 2016).

Traditionally within hospitals with multiple sub-specialty ICUs, such as a General ICU (GICU), Cardiothoracic (CICU), Neurosurgical (NICU) and in some cases a designated Trauma ICU, the units have been segregated physically and organisationally. Smaller standalone ICUs require similar organisational support mechanisms, physical infrastructure, resourcing and high staffing ratios to be maintained and available on a 24-hour basis across multiple sites within a single hospital. Furthermore, units with less than 300 annual admissions, 600 mechanical ventilation hours and low patient acuity may not maintain sufficient activity for process automation and limit opportunities for maintenance of staff skills and training (CICM 2014).

The aim of the hot-floor is to better balance efficiency and effectiveness (Costa & Kahn 2016; Skinner, Warrillow & Denehy 2015) through economies of scale, improved resource utilisation, reduced operational duplicity and enhanced standardisation of practice and processes (AHIA 2014; Fink 2015) while also continuing to improve outcomes for staff and patients (Iwashyna & Kahn 2014). The goal is to create a flexible and highly reliable organisational model that is safe, responsive to changing operational conditions within the available resources, and to promote a positive work environment (Roberts, Clark & Rock 2013).

At the time of this study 5% (n=8) of the 161 ICUs nationally represented the hot-floor model (ANZICS CORE 2014a) with increasing adoption driven by policy and planning imperatives (AHIA 2014). Typically bed capacity ranges from 50-70 beds, in contrast to 8-16 beds for a conventional (traditional standalone) ICU (AHIA 2014; CICM 2011).

The combined closed and open hybrid organisational model relies on a high level of collaboration between intensivists and sub-speciality medical staff on patient triage for admission, direct access to designated beds and clinical management goals. The aim is to optimise access for both planned (post procedural) and unplanned (emergency) activity while planning for routine 'business as usual' operational contingency that is resilient to changing conditions and ensures clinical quality and safety (Ravitz & Pronovost 2015).

A high degree of process standardisation, an agile workforce that can be readily mobilised, and effective leadership are essential enablers for organisational flexibility and reliability (Padgett et al. 2017). The hot-floor is presumed to fulfil these requirements and thereby emulate two key HRO principles, that is, *sensitivity to operations* (responding effectively to organisational conditions such as the availability of beds and a skilled clinical workforce) and *organisational resilience* (enhanced flexibility within existing resources) (Christianson et al. 2011). However, no evidence-based evaluation has been conducted of the model in terms of size, activity and patient throughput, the work environment or outcomes for nurses and patients.

1.3 Study purpose and significance

This study therefore seeks to determine if the ICU hot-floor model realises the presumed efficiency benefits associated with better demand management while achieving organisational effectiveness as reflected by patient and nurse outcomes. To address the knowledge gap this research compares a hot-floor and a conventional (traditional) ICU across quality management domains of organisational structure, processes and outcomes.

Limited evaluation of critical care organisational interventions is evident in the available literature (Pastores et al. 2015). Further examination is warranted to better understand the factors that will foster the emergence critical care organisational models that effectively manage population demand for intensive care and requirements for sustained reliability into the future. Through this process evidence based recommendations can be generated that support successful implementation and management of the hot-floor model as recommended in the Australasian Health Facility Guidelines (AHIA 2014) for new and redeveloped ICUs.

1.4 Research questions

The complexity of the ICU environment necessitates multiple factors to be studied. To satisfy this requisite the following research questions were explored:

1. What outcome measures, specific to critically ill patients, are mediated by organisational factors?
2. What outcome measures, specific to ICU nurses, are mediated by organisational factors and what is an appropriate survey instrument?
3. Is the closed (hybrid) hot-floor model capable of improving the management of intensive care demand?
4. Do hot-floor patient outcomes differ to those in a conventional ICU including the patient volume versus mortality association?
5. Does the hot-floor model influence nurse outcomes?

A quantitative study design was used to answer the research questions. The justification for the design is based upon the theoretical and philosophical assumptions, described in Chapter 2, which informed the conceptual framework for this research.

1.5 Thesis organisation

The structure of this thesis (see Table 1.1) initially outlines the impetus and background, organisational characteristics of the hot-floor compared to the conventional ICU, and the conceptual framework for the study.

Integrative literature reviews were performed to determine outcome measures associated with organisational factors and the ICU work environment. Outcome measures identified for patients, nurses and unit level effectiveness constitute the minimum datasets used to evaluate the hot-floor model. Nurse outcomes identified provide the basis for selection of the survey instrumentation used in the study. The methods employed and subsequent results are then presented concluding with a discussion of the findings.

Table 1.1 Thesis structure

#	Chapter Summary
Chapter 1 Introduction	Provides the impetus, purpose and research questions for the study.
Chapter 2 ICU organisation	Describes ICU organisation and its evolution, clinical service delivery, models of care and intensive care capacity planning. Operational management structures and quality management processes are also described to establish the organisational context in which the research program was conducted and highlight gaps in the literature. Theoretical and philosophical foundations that underpin the conceptual framework for the research program are established.
Chapter 3 Literature review	Presents the changes encountered to structural factors and processes due to organisational transition from the conventional ICU model to the hot-floor. Patient and nurse outcome measures were determined through integrative literature reviews. A published review paper on the patient volume-mortality association is highlighted along with a second published manuscript that provides justification for the nurse outcomes used and the survey instruments selected to evaluate the work environment.
Chapter 4 Methods	Study design, procedures, data management, analysis and ethical approvals are summarised. Sample size estimates and recruitment criteria for patients and nurse participants are then confirmed.
Chapter 5 Results	Attributes of the study settings are presented and compared including organisational structures and patient throughput efficiency measures. Randomly selected patient samples are then described including casemix and demographic characteristics, which serve as controls to compare the typically heterogeneous patient populations, followed by patient outcome results. Nurse sample profiles are then described and results of the ICU nurse survey are presented on work and demographic questions, the practice environment and burnout.
Chapter 6 Discussion	Provides a synopsis of results and interprets the study findings in regard to the impact of the hot-floor model, advantages and disadvantages, achievement of high organisational reliability. The implications for service planning, management and policy are then proposed along with potential future research ion the organisation of ICU and the hot-floor model.

2 ORGANISATION, PROCESS, WORKFORCE AND QUALITY

Intensive care as a clinical specialty evolved more recently than others such as surgery and obstetrics (see Figure 2.1).

Evolution Milestones

1543-1555	• Europe, intermittent positive pressure ventilation (Versalius 1555)
1854-1885	• UK, ICU model first introduced (Nightingale 1863), Australia Royal Prince Alfred Hospital established the first post operative recovery ward
1902-1916	• Europe, automated respiration (Matas 1902), Oxygen pressure chamber (Sauerbruch 1904), Rhythmic insufflation (Giertz 1916)
1927-1929	• US, iron lung (Drinker & Shaw 1927, Emerson 1929), US, post operative ICU (Dandy 1929)
1947-1955	• Scandinavia, piston ventilator (Morch 1947), Polio pandemic requiring mass mechanical ventilation (Lassen 1952), Denmark, first ICU (Ibsen 1953), Denmark long term ventilation (Bjork & Engstrom 1955)
1955-1960	• US, Canada and Europe, proliferation of respiratory and post surgical ICUs, US, modern ICU based on 'shock ward' model (Weil 1960)
1960-1980	• US, UK and Europe, postoperative/respiratory ICUs proliferate, Australia first ICU St Vincent's Hospital Vic. (1961), St Thomas' Hospital London 24/7 Intensivist cover (Spencer 1966), ICU nursing specialisation, Microprocessor ventilator (1971), Dedicated physiotherapists, pharmacy & other allied health, Professional societies established, ICU accreditation
1980-2017	• General ICUs transitioning to specialty cardiothoracic, neurosurgery & trauma services, ICU 'hot-floor' model emerges, High dependency beds in select ICUs, Predictive patient outcome modelling & case mix adjustment, Increasing point of care complexity, Extracorporeal support therapies, ICU outreach and rapid response teams, End of life planning

Figure 2.1 Key milestones in the evolution of ICU as a clinical specialty

Development of intensive care stemmed from the recognition that patients with a life-threatening illness or injury could be better managed when concentrated in dedicated specially equipped and staffed units (Grathwohl & Venticinque 2008). Florence Nightingale was credited with initially grouping the most severely injured soldiers closest to nursing stations in wards during the Crimean War (Wiles & Daffurn 2002). An examination of the relationship between management of military trauma and the organisational characteristics of the ICU concluded that Nightingale's organisation of nursing care established the concept for intensive care wards (Grathwohl & Venticinque 2008).

The polio epidemic of 1947-48 spread through Europe and the US, resulting in an eventual breakthrough in the treatment of respiratory paralysis (Frost 1976) and the proliferation of respiratory ICUs. General ICUs for critically ill and postoperative patients were subsequently developed for similar reasons (Kelly et al. 2014; Takala 2014; Weil & Shoemaker 2004). Cardiothoracic surgery was the main driver for small ICUs being established during the 1950s – 60s for postoperative recovery (Carlson, Weiland & Srivathsan 1996; Fairman & Kagan 1999). The Society of Critical Care Medicine (SCCM) then recommended promulgation of the ICU model to a broader range of critically ill patients (Weil & Tang 2011). Subsequently, sub-specialty ICUs began to emerge with multiple units being established within large tertiary hospitals, and progressive amalgamation of these units resulting in evolution of the integrated critical care service hot-floor model.

2.1 ICU organisation and model of care

The terms intensive care, high dependency care and critical care are generally used interchangeably to describe clinical management of patients with a critical illness. In an acute hospital the ICU provides a pivotal clinical support service for medicine, surgery, emergency and, in tertiary hospitals, clinical sub-specialties including cardiac surgery, severe trauma, transplantation and neurosciences. As a central clinical support service (see Figure 2.2) ICU activities aim to respond efficiently to operational fluctuations from multiple sources to support patient flow, and effectively facilitate clinical goals and outcomes for a broad range of patient cohorts.

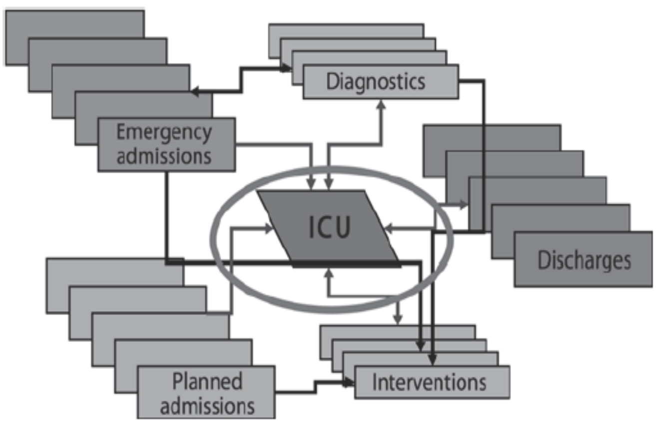


Figure 2.2 ICU as a central clinical support service

(Regli & Takala 2006a)

Admission sources include postoperative recovery, emergency, inpatient wards due to clinical deterioration and inter-hospital transfers. In addition to patient referrals the ICU increasingly plays a role beyond its physical perimeter, providing hospital wide rapid response and extended clinical support services such as vascular access and total parental nutrition. Maintaining these services, while ensuring timely access to beds and controlling unit occupancy at a level that supports a healthy work environment, without sacrificing the safety of patients transitioning to wards due to premature discharge, is a constant organisational challenge (Eriksson et al. 2017). An ICU demonstrates high organisational reliability where high-risk clinical activities are efficiently managed and effectively executed according to evidence based clinical and organisational standards (Sutcliffe, Paine & Pronovost 2017).

In 2009 the 'Declaration of Vienna' (Moreno, Rhodes & Donchin 2009) mandated physical and operational standards for organising the care and ensuring the safety of critically ill patients. This foundation for the development of standards was adopted internationally (Paiva 2015) by the Society of Critical Care Medicine (SCCM) and European Society of Intensive Care Medicine (ESICM) (Thompson et al. 2012; Valentin & Ferdinande 2011). In Australia, the College of Intensive Care Medicine (CICM) (2011) stipulates minimum standards for structural or physical inputs, operational and clinical processes, staffing and quality management, and are available at https://www.cicm.org.au/Resources/Professional-Documents#Policies. Standards are stratified into three levels of ICU services ranging from level one with low patient volume and complexity typical of a small district hospital, to level three found in a tertiary hospital with a large patient volume and high complexity.

Planning principles adhere to these standards (AHIA 2014) to support the level of service complexity to be delivered (Djukic et al. 2010; Halpern 2014). In Australia, the AusHFG promote three physical layouts for intensive care based on the closed ICU model including the standalone conventional General ICU (GICU), combined coronary critical care unit and the integrated ICU hot-floor model where segregated sub-specialty ICUs exist within a single hospital. Increasing emphasis on organisational factors reflects changing perceptions about what contributes most to improve staff and patient outcomes (Frankel & Moss 2014; Hung et al. 2013). Despite promotion in the AusHFG guidelines, little evidence exists on the benefits and limitations of these organisational models. The aim of this study is address this gap by comparing the conventional ICU model with the hot-floor model according to CICM and international recommended standards (see Table 2.1).

Table 2.1 Organisational and structural characteristics (2013 to 2014)

ICU Organisational Attribute	Recommended Structural Factors	Conventional [1] Model	Hot-floor Model
		(✓ Denotes requirement present)	
Physical Environment	• ICU layout and functional relationships	✓ Centralised	✓ Geographically dispersed pods
	Distinct organisational and geographic entity for clinical activity and care	✓	✓
	• ICU size ≥ 8 beds	✓ 8-16 beds	≥ 24 – 70 beds
	• Bed type ICU with or without HDU	ICU	ICU + HDU
	• Patient volume for sufficient admissions to ensure quality of performance for clinical interventions while avoiding operational fatigue, access block (>400 mechanically ventilated patients per annum)	✓	Increase patient throughput or volume per bed
	• Occupancy ~ 75%	✓	Increased
	• Appropriate equipment e.g. all beds with equivalent equipment	✓ Dedicated	Decentralised
	• Adequate resources	✓ Controlled	High fluctuating consumption
	• Isolation room ratio of 2 rooms per 8-10 beds	✓	Higher ratio with all single rooms common
	• Patient visibility	✓ Good	Reduced
	• Traffic management	✓ Controlled	Higher
	• Noise level	✓ Controlled	Higher

1. Collated recommended by international and local professional colleges and societies mandated by accreditation criteria (CICM 2011, 2014; Thompson et al. 2012).

The conventional ICU is an organisationally and geographically segregated unit typically with ICU beds situated round a central staff station (see Figure 2.3). There is a single ICU bed type that has, in the Australian context, a default one nurse to one patient ratio (AHIA 2014) limiting operational flexibility.

Patient volume is controlled by stringent triage criteria such as need for mechanical ventilation (Torra et al. 2016) and unit occupancy is typically 25% lower than the available capacity to provide operational contingency if required (Jones 2010; Tierney & Conroy 2014). Limitations include delayed access (Halpern 2011; Howell 2011), premature discharge (Tanaka & Ramaiah 2014) and increased inter-hospital transfers of critically ill patients (Sokol-Hessner et al. 2016).

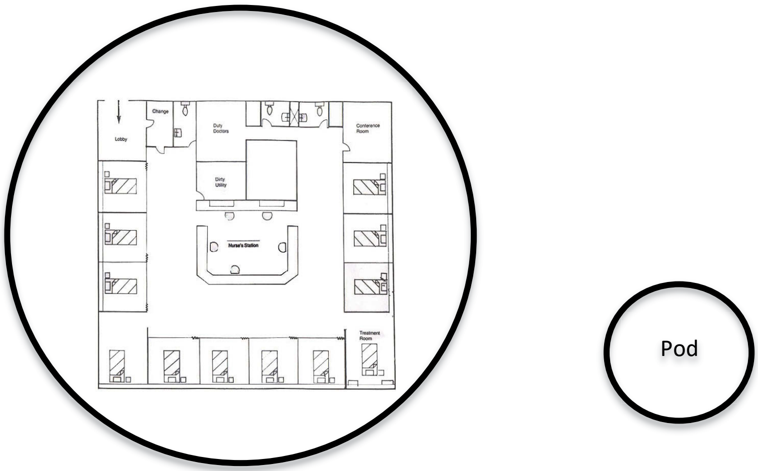


Figure 2.3 Conventional (traditional) ICU conceptual model

In contrast, the hot-floor has a large bed capacity geographically dispersed across multiple clinical pods (units), each representing a critical care sub-specialty in a designated area, that shares common administrative, utility and staff support areas (see Figure 2.4).

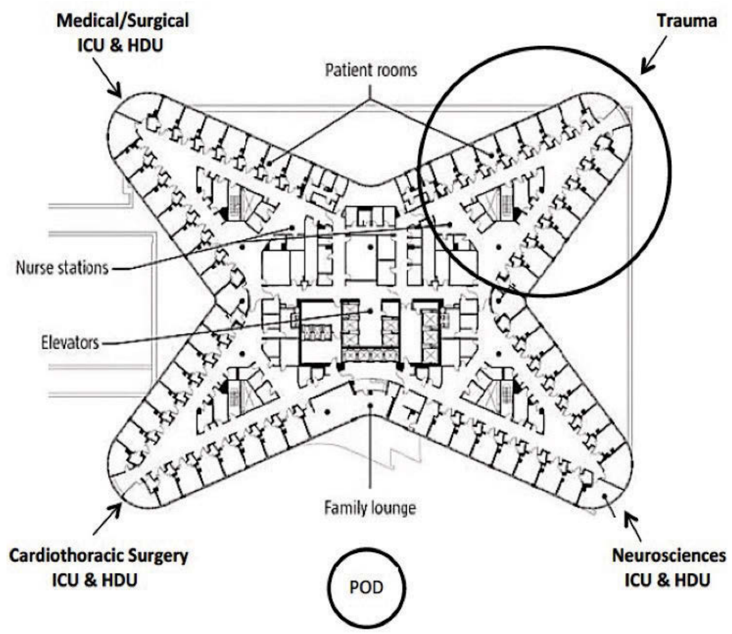


Figure 2.4 Conceptual representation of the hot-floor model

The progressive organisational shift towards an integrated service model of clinical sub-specialty conventional ICU pods has recently been described by Rashid (2014b) and the assumed benefits of segregated sub-specialty units are being challenged. For example, a large retrospective cohort study of risk adjusted outcomes of 84,182 patients across 124 ICUs by Nguyen and Milbrandt (2009) concluded that there was no significant difference in length of stay or survival between specialist units and integrated general ICUs. Organisational segregation that promotes super-specialisation of staff has also been implicated in limiting workforce mobility across units within a single hospital (Parmeshwar, Vishwanathan & Kumar 2015; Timmers, Joore & Leenen 2014; Vincent & Rubenfeld 2015). Staff development through a mentored clinical rotation program with frequent rotation cycles can be effective but unfamiliarity with the work environment, local clinical staff and a sense of lost clinical expertise and autonomy may undermine this strategy (Kramer & Zygun 2011).

This limitation may be exacerbated during periods of peak activity when patients need to be distributed across sub-specialty units, but this is restricted due to staff being unable to manage a broader range of patient diagnoses and associated clinical interventions impeding any operational contingency (Estabrooks et al. 2005; Meadows, Rattenberry & Waldmann 2011). In addition potential efficiency due to benefits from economies of scale for the management of goods, services and human resources is lost due to organisational silos (Garland 2013; Stock & McDermott 2011).

In contrast, seamless functional relationships (Meadows, Rattenberry & Waldmann 2011), enhanced standardisation (Reddy & Guzman 2015) and shared resource utilisation is enabled by service integration across multiple pods within the hot-floor. Different bed types across the whole service create greater flexibility within the available bed capacity (Scala 2012). Broader standardisation of care protocols, equipment, shift patterns, education and training facilitates workforce transferability (Buchan et al. 2017). Enhanced staff agility supports improved matching of skillmix and ratio's with patient acuity to create responsive and resilient organisational contingency for timely patient access (Dodek, Keenan, Norena & Wong 2010).

Improved access to ICU beds particularly for unplanned admissions has been suggested (Harris, Singer, et al. 2015) along with better support for patients transitioning to lower intensity wards due to the direct internal access to intermediate care beds. Importantly, this may reduce after-hours transfers (after 6pm and before 6am) and unplanned readmissions (Gopal, Terry & Corbett 2010; Hanane et al. 2008; Kramer, Higgins & Zimmerman 2012). The risk of mortality is reported to increase due to after-hours discharge though the association is not definitive. In a study of 76,690 ICU patients by Pilcher et al. (2010), 18.2% of patients discharged after-hours had a higher readmission rate (6.3% vs. 5.1%, $p < 0.05$) and higher mortality (8.0% vs. 5.3%, OR 1.42, 95% CI 1.32-1.52; $p < 0.0001$). Conversely, a more recent study of a similar population of 8,539 patients of which 16.4% were discharged after-hours, found mortality for each group 4.8% and 7.4% respectively ($p < 0.001$) but after risk adjustment for illness severity after-hours discharge was no longer a significant predictor of mortality (Santamaria et al. 2015). Though the association with patient outcomes may be controversial, the added risks associated with after-hours discharge are well documented with any reduction considered beneficial (Gantner et al. 2014; Santamaria et al. 2011).

Timely access, high patient through put and lower after-hours discharge rates assumed to be characteristic of the hot-floor infers that a relatively higher volume of patients and unit occupancy can be effectively managed due to greater operational flexibility. Increased volume has been associated with improved mortality outcomes for ICU patients with a high severity of illness though this is not consistent for all patient cohorts (Shahul et al. 2014; Sjoding et al. 2015; Walkey & Wiener 2014). An integrative review by Abbenbroek, Duffield and Elliott (2014a) (see Appendix 1) of studies into the association between patient volume and mortality in ICU suggests an upper volume threshold exists at which point the mortality benefits of volume are lost, an observation also supported by later reviews (Kuiper & Girbes 2015; Reddy & Guzman 2015). However, thresholds have been found to vary across clinical conditions, such as respiratory failure and sepsis for example, as the volume-outcome relationship may be related to the complexity of diagnosis and management in these conditions (Nguyen et al. 2015).

Contributing factors are not well defined but increased workload and operational fatigue may lead to a break down in clinical processes, increasing risks for iatrogenic adverse events when the balance between volume and workload is not effectively managed (Abbenbroek, Duffield & Elliott 2014a; Iwashyna, Kramer & Kahn 2009; Manojlovich, Antonakos & Ronis 2010). High unit occupancy has been found to exacerbate volume and workload (Halpern et al. 2006) further putting patient outcomes at risk (Haerkens et al. 2015) and the work environment may also be compromised subjecting staff to greater risk of dissatisfaction and burnout (Bagshaw et al. 2017). Burnout is characterised by emotional exhaustion associated with depersonalisation and decreased personal accomplishment to a point where fatigue, exhaustion, and detachment coalesce and clinicians feel they no longer contribute meaningfully (Lyndon 2016; Tourangeau, Cranley, et al. 2010).

2.2 Operational management and care processes

The CICM guidelines recommend that ICU operations and clinical care processes are carried out according to a defined policy framework and evidence based protocols. Operational management and clinical processes are compared in Table 2.2 for both ICU models. High organisational reliability and CICM standards require these activities to be regularly audited and benchmarked against other units to ensure continuous quality improvement and drive an active research program into factors that contribute to positive outcomes.

Table 2.2 Operational management and clinical processes (2013 to 2014)

Organisational Attribute	Required Process Factor	Conventional [1] Model (✓ Denotes requirement present)	Hot-floor Model
Operational Management	• Operates as a 'closed' unit managed by the ICU team	✓	Hybrid model with increased external team involvement
	• 24-hour access to pharmacy, pathology, operating theatres and medical imaging services	✓	✓
	• Timely access to ICU beds	Bed base inflexibility	Bed flexibility may improve access
	• Clinical specialisation	General	General plus subspecialties
	• Controlled patient casemix e.g. diagnosis, complexity, severity of illness via triage	✓ Controlled	High variability
	• Flexible patient flow	Limited	High flexibility
	• Work undertaken outside the ICU including outreach service	✓	✓
Clinical Processes	• Multidisciplinary team rounds for patient review	✓	✓
	• Defined daily treatment goals	✓	✓
	• Standardisation	✓	✓
	• Protocols, checklists and guidelines for clinical practice	✓	✓
	• Compliance with clinical prophylaxis regimes e.g. 'FASTHUG'	✓	✓
	• Structured shift handover	✓	✓

1. Collated requirements recommended by international and local professional colleges and societies mandated by accreditation criteria (CICM 2011, 2014; Thompson et al. 2012).

Both models are similar for a majority of operational and clinical processes though some differences are evident. The hot-floor promotes greater involvement of specialist clinical teams in the control of admissions and coordination of clinical management within the assigned sub-specialty pod. The 'purist' closed ICU model is modified to create a hybrid model that incorporates elements of both closed and open operational policies for admission. That is, the specialist team predetermines its elective admission list independently to the intensivist but adjusts to accommodate unplanned activity triaged by the intensivist as required. Optimising this balance to achieve stronger specialist team engagement may have a positive impact on patient outcomes (Kramer & Zygun 2014; Yoo et al. 2014). Successful management of an interdisciplinary ICU hot-floor therefore requires a philosophy that encourages staff to cross-specialise with appropriate training to foster a broader skill mix that can maximize staffing flexibility (Pati, Harvey & Cason 2008) and foster interdisciplinary collaboration (Regli & Takala 2006b; Yoo et al. 2014).

Regardless of the organisational model, timely patient access to ICU is imperative to minimise any delay to definitive treatment that may adversely affect patient outcomes (Cardoso et al. 2011; Hung et al. 2014). Effective operational management requires planned contingency for fluctuating bed demand, supported by an appropriately skilled and agile clinical workforce (Patri & Suresh 2017). As an integrated service model, the hot-floor promotes cross-specialisation of staff creating greater contingency than the conventional ICU to meet demand. A broader range of patient dependencies may also permit alternative nurse:patient ratios beyond the traditional one nurse to one patient ratio (ACCCN 2016) to further enhance operational flexibility. These operational qualities suggest the hot-floor model may possess a higher resilience to changing conditions, an essential quality for high organisational reliability (Aboumatar et al. 2017).

Both models promote a high level of multi-disciplinary collaboration, structured clinical rounds and standardised evidence based practice. However, a factor that may impact on organisational effectiveness of the hot-floor may be large bed capacity and unit size requiring a larger number of patients to be reviewed during clinical rounds and limited time available for clinical assessment and planning of patient care (Ward & Howell 2015). Organisational characteristics such as size and physical layout have been suggested as influential factors for the adoption of care processes (Dodek et al. 2012; Frankel & Moss 2014) that can affect patient outcomes.

Additionally, the degree to which an ICU is operated as an open versus closed model may influence the level of standardisation and compliance achieved (Checkley et al. 2014; Daneman et al. 2013; Treggiari et al. 2007). In contrast to an apparent high level of standardisation, large multi-speciality ICUs may have a lower level of clinical standardisation due to increased involvement of external primary clinical teams in patient care (Matlakala, Bezuidenhout & Botha 2014a). The potential impact of external clinical teams directing ICU clinical care is however not well understood, highlighting the need to evaluate this collaborative model (Garland 2013).

An early study of patient characteristics and outcomes at University Hospital of Berne (Regli & Takala 2006b) provides some insight into the influence of these factors. Before and after transition to a hot-floor model, length of stay and patient mortality were monitored from 1998 to 2003 (see Table 2.3).

Table 2.3 University Hospital of Berne: ICU patient data from 1998 to 2003

	1998	1999	2000	2001	2002	2003
# of patients	2,799	2,682	3,029	3,221	3,081	3,338
SAPS-2 score (mean)	29.8	30.2	28.3	28.0	29.5	29.3
LoS ICU days (mean)	3.6	3.4	2.8	2.4	2.3	2.4
Age (mean)	60.1	59.9	60.8	59.6	60.0	59.5
Mortality (%)	8.2	7.7	6.5	5.6	6.0	5.5

SAPS: Simplified Acute Physiology Score, LoS: Length of Stay. Source: Regli & Takala (2006) pp: 118.

In this scenario five separate specialty ICUs were merged into a hot-floor in 1999. After the merger a sustained reduction in the mean length of stay from 3.6 days to 2.4 days was observed. The mortality rate also demonstrated a sustained decrease from 8.2% to 5.5% despite an increase in activity and no change in mean patient age or severity of illness. Improved patient outcomes were therefore attributed to enhanced operational synergies and improved compliance with standardised evidence based practice following colocation of previously segregated sub-specialty units into an integrated hot-floor model (Regli & Takala 2006b).

2.3 Workforce

The ICU workforce consists of multidisciplinary professional groups collaborating in a highly structured team to provide clinical management to critically ill patients (Curtis et al. 2006). The team is typically led by a senior medical clinician and coordinated by a senior nurse or nursing manager with ancillary and administrative staff providing essential clinical support (Curtis et al. 2006; Young & Birkmeyer 2000).

Intensive care requires high human resource inputs; at least 55% of total ICU costs relate to staffing (Bertolini et al. 2003; Eager 2006). As previously noted, the standard ICU model of care in Australia is based on Registered Nurse (RN) staffing ratios of one nurse to one patient across 24-hours (CICM 2011), one of only a limited number of countries that has adopted this nurse staffing model nationally in ICU. This ratio is also specified by the Australian College of Critical Care Nurses (ACCCN 2016; Williams 2009).

The relationship between the nurse to patient ratio and staff skill-mix, and adverse events and quality of patient care in acute care settings has been studied extensively internationally (Clarke et al. 1999; Harding & Wright 2014; Neuraz et al. 2015; Penoyer 2010). Collectively there is definitive evidence on the negative impact of reducing the ratio of registered nurses providing direct patient care in ICU (Falk & Wallin 2016; Pastores 2015). Patient outcomes including rates of hospital acquired infections, pressure ulcer incidence, medication errors and delayed detection of clinical deterioration are associated consequences (Penoyer 2010; Shekelle 2013; Thompson et al. 2013).

While staffing, as a major driver of costs is easily quantifiable, the cost saving opportunities associated with patient outcomes are not so evident. An early prospective study of 80 Italian ICUs examined core ICU characteristics including unit type, bed capacity, activity, occupancy, average length of stay, mortality rates and tertiary affiliation in relation to labour costs per ICU patient (Bertolini et al. 2003). A link between labour costs, mortality and length of stay was found along with an inverse relationship between increasing bed numbers. A threshold of 12 ICU beds was the point at which costs decreased and remained relatively stable as bed numbers continued to increase (see Figure 2.5) and the study concluded that small ICUs (<6 to 10 beds) were too costly in terms of labour-based resources.

Subsequent ICU costing studies supported the association between cost efficiencies and a larger ICU capacity (Edbrooke et al. 2011; Rossi et al. 2006; Tan et al. 2008). Staff turnover is also a major factor contributing to labour costs, and is associated with not having staff available, casual staff requirements for replacement, recruitment, orientation and training costs; all collectively contribute to decreased productivity (Duffield & O'brien-Pallas 2002).

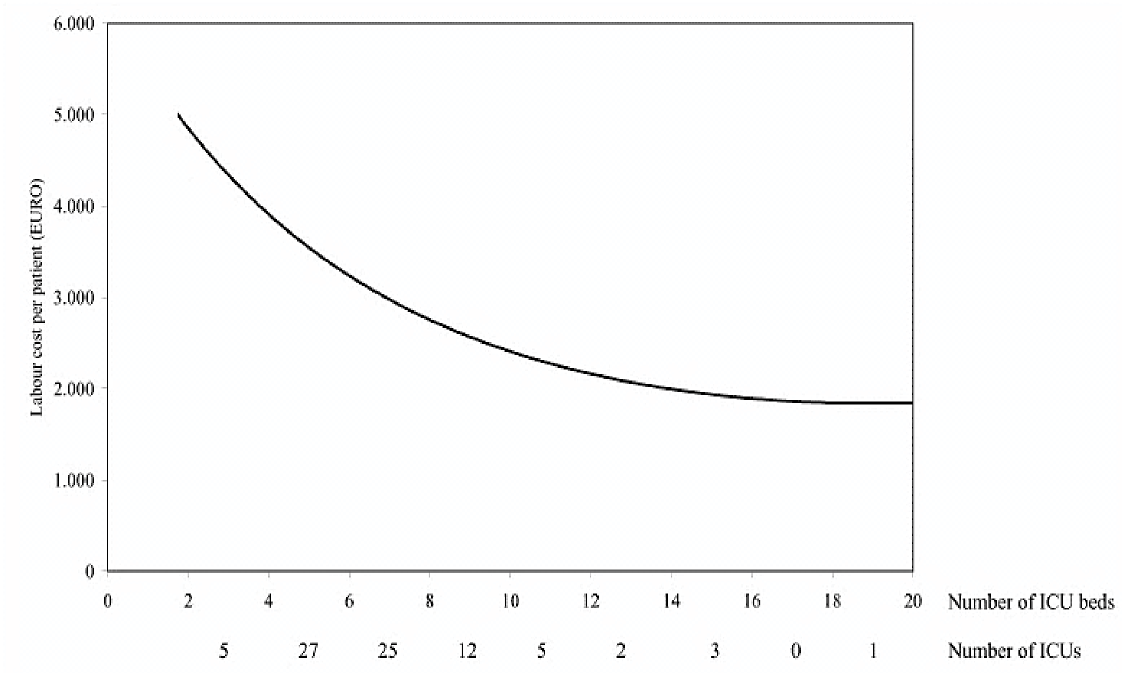


Figure 2.5 Relationship between labour costs and number of ICU beds

Source: (Bertolini et al. 2003) pp.2309

Critical care nurses have a relatively high attrition rate compared to other nursing specialties (Laporta, Burns & Doig 2005; Mosallam, Hamidi & Elrefaay 2015). Intensive care nursing is demanding both physically and emotionally with a high proportion of time spent on night duty. Increased attrition of experienced critical care nurses reduces the proportion of proficient qualified staff; this impact is exacerbated in large tertiary ICUs where the point of care is becoming increasingly more complex (Laerkner, Egerod & Hansen 2015); an important issue when exploring the impact on staffing of the hot-floor model.

The Australian College of Critical Care Nurses (ACCCN) Workforce Standards for Intensive Care Nursing (2016) and the CICM Minimum Standards for Intensive Care Units (2011) clearly articulate workforce requirements in relation to unit size and complexity. Importantly, ACCCN nursing workforce standards are supported by CICM, which also outlines workforce standards for medical, allied health and ancillary support staff. Table 2.4 summarises the workforce characteristics of the conventional and hot-floor model according to recommended professional standards.

Table 2.4 Workforce characteristics (2013 to 2014)

Organisational Attribute	Characteristic	Conventional[1] Model	Hot-floor Model
		(✓ Denotes requirement present)	
Staffing	• Patient allocation	1.1	1:1, 1:2, 1:4
	• Skill mix e.g. nurses ICU qualified > 50%	✓	✓ Lower in a large staff cohort
	• Dedicated qualified nursing manager[1]	✓	✓ Responsible for multiple units supported by nurse unit manager during business hours
	• After-hours ICU Nurse Manager	Unit Team Leader	✓ Responsible for multiple units supported by unit team leaders
	• Clinical education (1 FTE: 50 nurses)	1 per unit (< 1 FTE: 50)	Less than 1 per unit due to responsibility for multiple units
	• ACCESS[2] nurse ratio 1: 4 beds to 1: 8 beds	1 per unit (< 1:8 beds)	< 1 per unit due to responsibility for multiple units and well below recommended standards
	• Equipment manager (Nurse)	✓	✓
	• Nursing liaison service	✓	✓ Larger cohort of patients required for follow up
	• Research nurse	✓	✓ Required to coordinate trials and practice research across multiple pods
	• Typical nursing staff cohort	90-100 FTE	200-300 FTE
	• Medical Director	✓	✓Responsible for multiple units
	• Senior medical staff (clinical) business hours.	1 FTE: 8 -15 beds	1 FTE per pod of 8-15 beds
	• Senior medical staff (clinical) afterhours	1 FTE: 8-15 beds	1 FTE for > than 15 beds in multiple units
	• Medical staff – rapid response and extended ICU role	1FTE	1 FTE for multiple units
	• Allied staff including pharmacist and physiotherapist	✓	✓Responsible for multiple units
	• Ancillary clinical support and clerical staff	✓	✓Responsible for multiple units

1. Qualified leadership i.e. Medical Director is a Fellow of CICM (CICM 2011) and the Nursing Manager ICU qualified (ACCCN)
2. ACCESS nurse provides Assistance, Coordination, Contingency, Education, Supervision and Support (ACCCN 2016) with ratio dependent upon the proportion of qualified ICU nurses.

Comparing staffing characteristics demonstrates close alignment in workforce structures for nursing, medical, ancillary and allied health positions between both ICU models. The key difference is the level of resourcing required for each model. The hot-floor uses a greater range of nurse to patient ratios for staffing. This may support greater operational flexibility through more options for staff allocation to respond to changing activity and acuity, and manage hospital demands for clinical support outside the ICU (Jones et al. 2012; Salvatierra et al. 2014). The ability to better match less experienced staff with lower acuity and less complex patients may provide a staggered introduction to the ICU environment for progressive skill acquisition. The large staffing cohort required for the hot-floor may mean the proportion of ICU qualified staff remains well below the optimal level of 75% (CICM 2014) with more reliance on less experienced nurses to staff the available beds.

Nurses working outside their skill levels may increase the risk for sub-optimal, and in some cases, hazardous delivery of care (Rischbieth 2006). This increased need for mentorship and supervision therefore places more pressure on senior clinical staff over prolonged time periods, potentially contributing to increased burnout and turnover (Cho et al. 2009; Knani & Fournier 2013; Lewis et al. 2014).

In the high-risk ICU environment effective supervision requires adequate resourcing of front-line management, education and clinical support roles, relative to the size of the clinical workforce, beds and pods to ensure patient safety and promote staff welfare. Health organisations may seek efficiencies in staffing by sharing roles across multiple units rather than incrementally increasing resources in line with the size of the service. Under resourcing of key roles may reduce their effectiveness and limit the success of the hot-floor in fulfilling the requirements for high reliability, adversely affecting the work environment and staff and patient outcomes. The large bed capacity and clinical workforce warrants front-line nursing management positions allocated to each pod across 24-hours. This may be in the form of additional clinical nursing managers that oversee multiple ICU pods of beds, each of which also has a nursing team leader to coordinate and supervise clinical staff within the pod (ACCCN 2016). Whilst this represents an additional cost it does provide a whole of service view across multiple pods to manage staffing, skill-mix, resource allocation and patient flow, thereby optimising operational flexibility (Matlakala, Bezuidenhout & Botha 2014b).

Effective leadership, management, education and clinical support is also required to encourage compliance with evidence based clinical processes that underpin high quality care and safety, essential for patients with critical illnesses (Clarkson 2013; Gifford et al. 2013; Hewson et al. 2011). Resourcing, workforce characteristics, models of care, quality management initiatives (e.g. checklists) and effective leadership, influence the effectiveness of care processes (Byrnes et al. 2009). Visible, physically present, leadership is a strong determinant of how operational management and care processes contribute to patient and staff outcomes (Fink 2011; Moneke & Umeh 2014; Wong, Cummings & Ducharme 2013). Conversely, ineffective management and the lack of support for clinical staff are predictors of satisfaction and subsequently nurse retention (Duffield & O'brien-Pallas 2002; Tourangeau, Cummings, et al. 2010).

The nursing staff cohort of the ICU hot-floor may reach or exceed two hundred full-time equivalent positions, depending on bed capacity and configuration, but in practice a larger staff establishment (head count) is employed when part-time positions are considered. This large number of staff may have a detrimental effect on workforce satisfaction in terms of group dynamics, engagement, opportunities for learning and development, clinical support and supervision (Braungardt & Fought 2008; Matlakala, Bezuidenhout & Botha 2014a; Schreiter & Saeger 2011). Individual nurses may experience a sense of disconnection, reduced professional inclusion and depersonalisation in such a large staff cohort (Van Bogaert, Olaf, et al. 2013). Ultimately these attributes of the work environment and the detrimental impact on collegial communications may lead to worse patient outcomes including adverse events, failures in processes of care and increased mortality (Stalpers et al. 2015b; West et al. 2014).

The physical layout of the hot-floor with multiple clinical specialty pods may also break down the visual and social cohesiveness of a unit, impacting on group dynamics, collaboration and professional teamwork, particularly as ICU nurses are allocated to a single physical location for the shift (Djukic et al. 2012; Olausson, Ekebergh & Österberg 2014). Clinical cross-specialisation contributes to operational flexibility. However, when nurses are allocated to a different clinical specialty they may lose confidence in their skill and abilities, experience uncertainty that may impact patient care (Cranley et al. 2012) and create a sense of lost autonomy (Papathanassoglou et al. 2012; Twigg & McCullough 2014). Cross-specialisation requires staff to have consolidated experiences in core clinical ICU skills and to be qualified in intensive care to confidently apply their knowledge and practical skills in an unfamiliar practice environment that also lacks a familiar collegial support network (Willem, Buelens & De Jonghe 2007).

Workforce skill-mix, specialisation, size and cohesion influence staff beliefs, values and the perceived value attributed to their work, all of which shape collective attitudes, behaviours and organisational culture (Tsai 2011). The quality of a work environment has a strong association with organisational culture, influencing staff outcomes, in particular job satisfaction (Tsai 2011). Behaviours and attitudes can be influenced by promoting the organisational ethos or culture to staff in a cohesive work environment where meaningful interaction occurs with managers, fostering effective communication and collaboration to the benefit of staff and patients (Timmers, Hulstaert & Leenen 2014).

A study of 2734 clinical staff in 23 Canadian tertiary and community ICUs found moderately strong correlations between the size of the ICU and several organisational culture domains (Dodek et al. 2011). Culture domain scores were generally favourable in all ICUs, with moderately strong positive correlations between number of ICU beds and perceived effectiveness at recruiting and retaining staff ($r = 0.58$; $p < 0.01$), quality of care ($r = 0.66$; $p < 0.01$) and medical director budgeting authority ($r = 0.46$; $p = 0.03$). Moderately strong negative correlations were observed with frequency of events reported ($r = -0.46$; $p = 0.03$) and teamwork ($r = -0.51$; $p = 0.01$). Differences in perceptions between staff in larger and smaller ICUs therefore highlighted the importance of teamwork across units in larger ICUs.

Underpinning a successful nurse workforce model for the hot-floor is the provision of adequate front-line management, education and clinical support resources. Solely increasing capacity, activity and clinical staff, without proactive planning and resourcing the complete workforce model, is not feasible and undermines potential benefits of the hot-floor (Reddy & Guzman 2015; Weled et al. 2015) and risks sustainability of the model (Iwashyna & Kahn 2014).

Similarly, senior ICU trained medical staff, or an Intensivist, is required to be present on all shifts to triage admissions and guide clinical care to maintain the quality of care and optimise patient outcomes (Baharoon et al. 2014; Wilcox et al. 2014). Both ICU models in this study employ this medical model, although the large bed capacity and high patient volume typical of the hot-floor may increase patient to Intensivist ratios (Ward et al. 2013). Importantly the ratio of senior medical staff to patients in ICU needs to keep pace as the demand for ICU increases and bed capacity grows. Senior clinical medical staff may be required to care for greater numbers of critically ill patients, which in the context of increasing complexity, reduces the available time per patient and to undertake other professional responsibilities (Ward et al. 2013; Ward & Howell 2015). Deterioration of patient care and clinical outcomes, staff wellbeing, workforce stability and teaching capability are a sign of insufficient staffing and must be proactively managed to maintain ICU accreditation are closely linked (CICM 2014). As a consequence of these factors the benefits expected from structural reforms are not realised (Braithwaite & Westbrook 2005; Dedman, Nowak & Klass 2011).

Furthermore, senior nursing and medical staff may also be required to respond to rapid response calls external to the unit for deteriorating patients in the hospital. Increasing work external to the ICU places additional demands on ICU staff, in turn limiting internal operational capability where no planned contingency exists (Jones, DeVita & Bellomo 2011; Mitchell, Schatz & Francis 2014).

A limited number of studies have investigated the association between the organisational attributes of large ICUs and their impact on staff outcomes (Dodek et al. 2011; Goldschmidt & Gordin 2006; Matlakala, Bezuidenhout & Botha 2014a). There are considerable challenges in establishing any causal relationships between organisational attributes and staff outcomes due to multiple confounders that may contribute to the strength of association (Garland 2010). Despite these challenges there is an imperative to explore the impact of the hot-floor organisational attributes and how these can be managed to optimise staff outcomes, promote high clinical quality and ensure sustainability (Garland 2010).

2.4 Quality management

Quality health care is safe, timely, effective, equitable and patient centric (Curtis et al. 2006; Tropello et al. 2013). Three domains of quality health care were identified in 1973 i.e. structure, process and outcome, which continue to be relevant in contemporary practice and to the evaluation of ICU organisational models (Donabedian 1988, 2005; Duke et al. 2005; Whittle & Shelton 2012). A fourth domain encompasses staff behaviours and beliefs reflected by an interdependent mix of communication, interactions, professional practice and conduct, team dynamics, power relationships, moral paradigms, knowledge and expectations (Dodek et al.

2011). This complex interplay of human factors influences, and is a result of work environment, climate and culture created by organisational structures, processes and the outcomes achieved (Wagner et al. 2014).

Structure refers to the organisation of care with sources of variation including how the ICU is integrated into the hospital or health care system, the size of the ICU, whether the unit is open or closed, the type and amount of technology available, and the number, roles, and responsibilities of ICU staff (Donabedian 2005; Whittle & Shelton 2012). Variation in these structural features can affect the quality of care and the potential for patient recovery from critical illness. For example, studies have suggested that patients managed in a closed ICU by physicians with critical care training have better outcomes than patients managed in open ICUs by generalists without critical care training (CACCN 2011; Dodek, Keenan, Norena, Martin, et al. 2010; Young & Birkmeyer 2000).

Process refers to the model of care delivery that encompasses what staff do, or fail to do, for patients and their families (Curtis et al. 2006; Donabedian 2005). Delivering high-quality care in the ICU requires the synchronous efforts of large numbers of clinical and nonclinical processes. Operational management processes are strong determinants of clinical quality (Paiva 2015; Pronovost et al. 1999; Reddy & Guzman 2015).

Outcomes refer primarily to the clinical results achieved following the delivery of critical care (de Vos et al. 2007; Donabedian 2005). The measurement of clinical outcomes in critical care has enabled risk-adjustment mortality models to be developed and the generation of standardised mortality ratios for comparison across ICUs (Curtis et al. 2006). However, quality clinical indicators such as adverse events, length of stay and unplanned readmission rates have been associated with patient outcomes and provide a more comprehensive assessment of service delivery (Kyeremanteng & D'Egidio 2015; van der Voort, van der Veer & de Vos 2012). Cumulative information is required on mortality, clinical interventions, operational management and patient throughput to evaluate performance (Garland 2005; Sawatzky, Enns & Legare 2015). Parameters evaluated must have a primary relationship with systems and processes for the delivery of care to provide a balanced assessment (Aidemark et al. 2010; Ben-Tovim 2010; Brett 2011).

The Australian and New Zealand Intensive Care Society (ANZICS) Australian Patient Database (APD) and Centre for Outcomes Research (CORE) Critical Care Resources Survey (CCRS) provides the linkage between clinical and administrative ICU data (ANZICS CORE 2013b) and is used in this study for comparative purposes. Clinical and administrative datasets are however only two pieces of the quality evaluation puzzle. Work environment elements including staffing, skill mix, supervision and clinical support are also key determinants of quality of care (Clarke 2009) along with staff satisfaction and retention, all of which need to be factored in to evaluate ICU performance. A broad approach to outcomes measurement has therefore been adopted in this thesis, encompassing patient and nurse outcomes, and unit level measures of organisational effectiveness to evaluate the hot-floor.

2.5 Conceptual framework

To evaluate the relationship between ICU organisation and outcomes, an appropriate framework is required that embodies the philosophical principles and theoretical foundations previously described. The conceptual framework applied in this study is grounded in the early structure, process and outcomes model (Donabedian 1988) that presumes workplace organisational factors and structures affect processes and outcomes (see Figure 2.6).

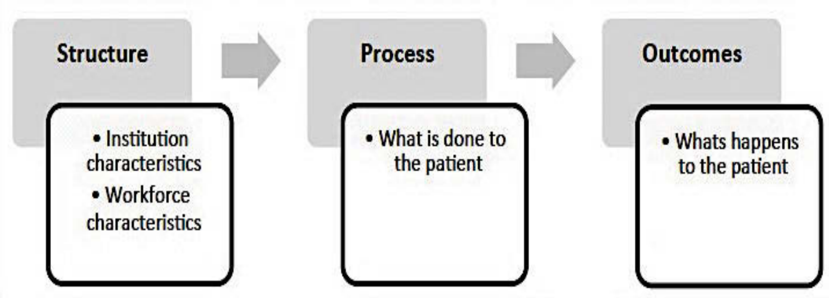


Figure 2.6 Donabedian quality framework

The model guides the development of quality improvement strategies (Kramer, Schmalenberg & Maguire 2010). However, the model does not comprehensively encapsulate the broader range of unit and nurse outcomes influenced by organisational factors collected for this research. More relevant is the conceptual framework defined in a multi-national study across 303 hospitals evaluating the impact of organisational support for nursing care on patient and nurse outcomes (Aiken, Clarke & Sloane 2002) as illustrated in Figure 2.7.

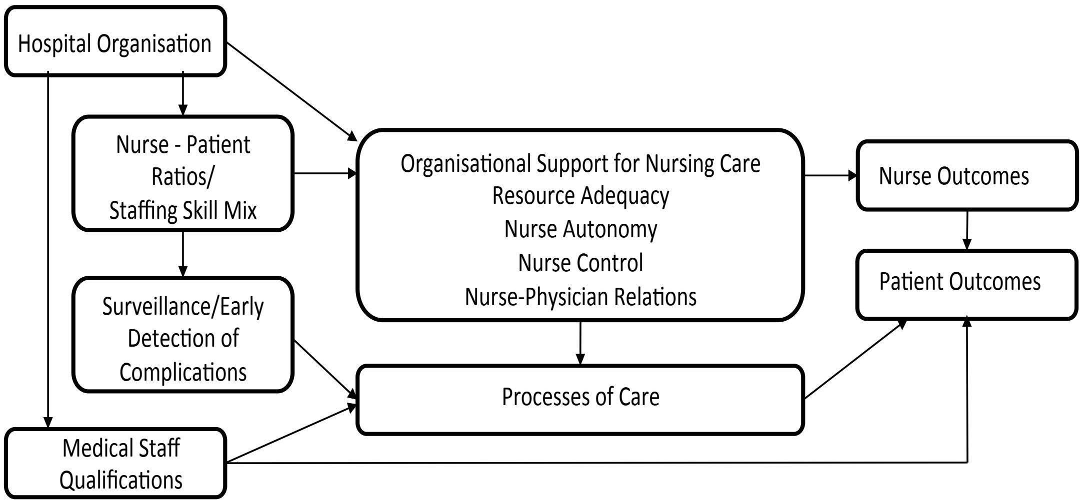


Figure 2.7 Interrelationships of organisational factors with nurse and patient outcomes

Source: (Aiken, Clarke & Sloane 2002) pp.7

In this model, outcomes are linked to organisational supports and inputs including staffing, skillmix, resourcing, workplace support and inter professional collaboration, which facilitate effective care processes. A high correlation was reported between these factors and nurse dissatisfaction and burnout, and patient outcomes (Aiken, Clarke & Sloane 2002), and conceptually aligns with the quality model proposed by Donabedian (2005).

However, one area of divergence from this study was the evaluation of patient outcomes using nurse reported quality of care (Aiken, Clarke & Sloane 2002) as opposed to the current study design which evaluates empirical unit, patient and nurse outcome data. As such, a study of empirical nurse, patient and organisational factors by Meyer et al. (2009), employing the early Patient Care Delivery Model (PCDM) (O'Brien-Pallas et al. 1997), better conceptualises the interdependent relationships between work environment factors and outcomes. Furthermore the PCDM aligns closely with the Donabedian (2005) and Aiken et al. (2002) models, and accounts for empirical nurse, patient and unit level outcomes (see Figure 2.8).

Inputs and structures create the organisational context that influences the work environment. Processes and throughputs determine what and how clinical interventions and patient care are delivered. Patient, nurse and unit outcomes comprehensively capture the impact of on these interrelated forces (Lankshear, Sheldon & Maynard 2005; Rafferty et al. 2005; Weled et al. 2015).

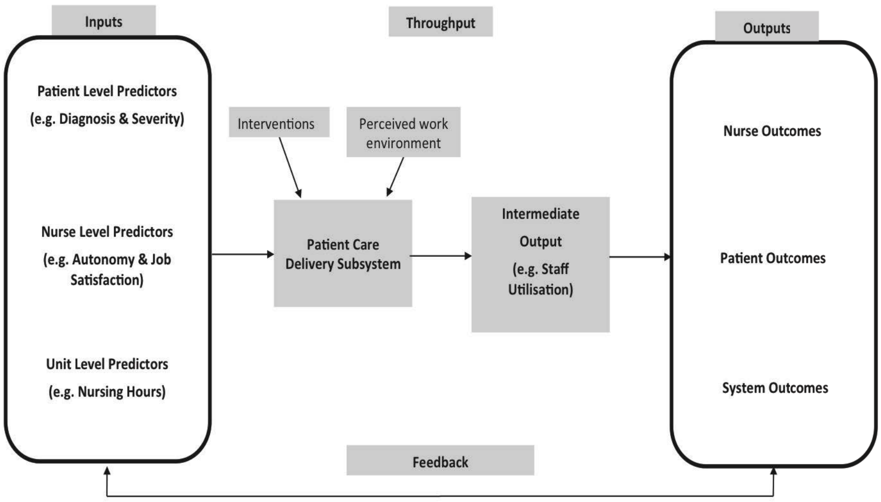


Figure 2.8 Patient Care Delivery Model

Source: (Meyer et al. 2009) pp. 400

Increasingly organisational factors and process measures are becoming a focus of quality management owing to the difficulty interpreting patient outcome measures in the critical care setting due to the heterogeneity of patients (Kyeremanteng & D'Egidio 2015). The conceptual framework (see Figure 2.9) for this study is therefore based on the PCDM as it encapsulates structure, process and outcome domains and aligns with the quality management model used in ICUs internationally (Murphy, Ogbu & Coopersmith 2015; Pronovost et al. 2008; Sakr et al. 2015). This conceptual framework guided the subsequent literature review and theoretical assumptions underpinning the study methods.

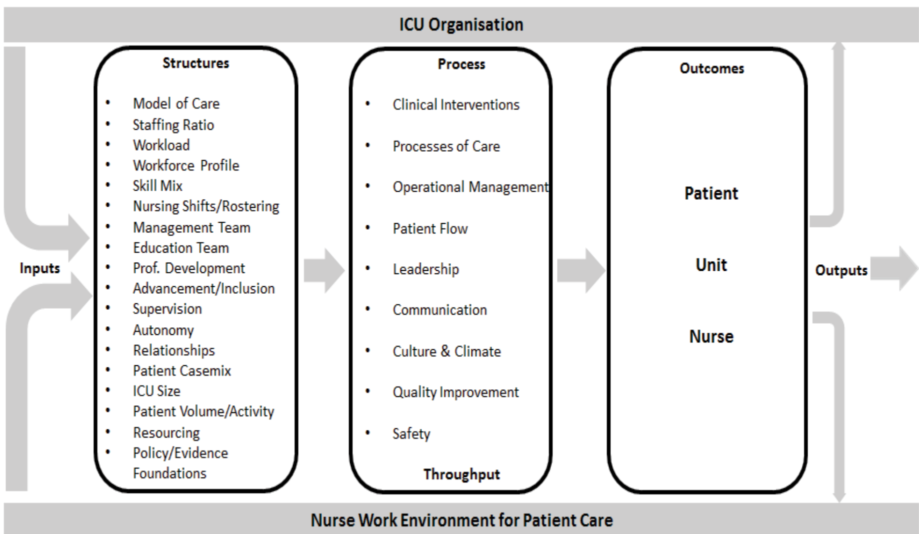


Figure 2.9 Hot-floor study conceptual framework

2.6 Summary

In this chapter the evolution of intensive care as a clinical specialty was described. Organisational characteristics, unique to the ICU, were identified thereby establishing the structural requirements of the traditional ICU. Organisational transformation in the form of regionalisation and consolidation of services is being driven by increasing demand, high resource utilisation, escalating costs and the need to maintain or improve the quality of care provided. These forces provide the impetus for the emergence of alternative ICU organisational models. As a result large capacity multi-specialty intensive care hot-floors are a priority in health service planning for new and redeveloped ICUs.

The key concepts described in this chapter enable a comprehensive understanding of intensive care service delivery in Australia, establishes the situational context for this research program and provides a framework to evaluate the ICU hot-floor model. Interdependent structure, process and outcome components of ICU quality management provide the conceptual foundations for this research. The impact of changes required to physical structures, operations and processes, changes on patient outcomes, nurse outcomes and organisational effectiveness has not been evaluated. Moreover, it is not known if the hot-floor achieves the assumed benefits attributed to this model. Understanding these phenomena is imperative to effective policy and planning to ensure sustainability.

Evidence based outcomes for patients and nurses, and unit level effectiveness measures mediated by organisational factors in ICU are required to operationalise the conceptual model to evaluate the hot-floor. In Chapter 3 integrative literature reviews, performed to identify pertinent evaluation measures for this study, are presented and the results incorporated into the methodology underpinning this research.

3 LITERATURE REVIEW OF ICU ORGANISATIONAL OUTCOMES

3.1 Introduction

Hot-floor organisational characteristics described in Chapter 2, and the assumed benefits of the model are summarised in Figure 3.1. Two separate literature reviews, each incorporating an integrative review stage, were conducted to identify appropriate variables to evaluate the impact of organisational factors on patient and nurse outcomes, and organisational effectiveness of each model.

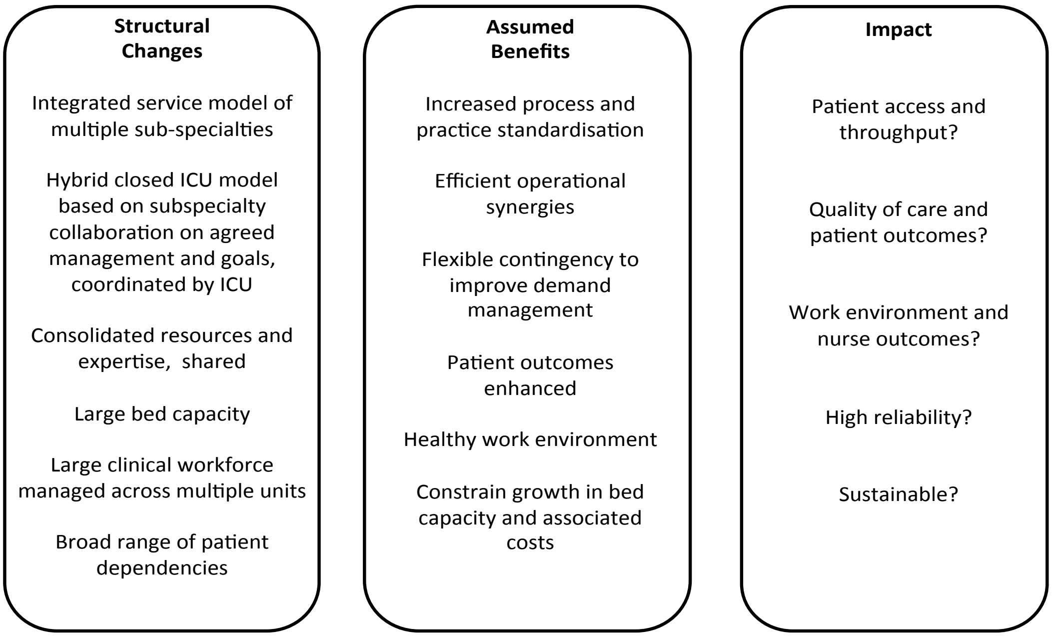


Figure 3.1 Organisational characteristics of hot-floor model

Organisational factors and processes influence nurse outcomes (Checkley et al. 2014; Dodek et al. 2015) and have a strong association with patient outcomes (Frankel & Moss 2014; Kesecioglu et al. 2012). However, the impact of different organisational models is not as well understood (Rashid, Boyle & Crosser 2014). In an early review of ICU design spanning a decade, Rashid (2006) observed that the organisational, spatial, social and behavioural implications of the multiple-pod ICU model were not well understood. Subsequently, two descriptive reviews of ICU organisation were undertaken again by Rashid (2011, 2014a), but focused primarily on therapeutic and staff work area design.

Organisational restructuring is a planned undertaking in which hospital management reorganises workflows, physically realigns services and units through mergers, rearranges and redefines jobs, and alters reporting relationships with the goal of reducing costs or increasing efficiency while maintaining or improving the quality of patient care (Burke, Ng & Wolpin 2011). Health reforms adopted to improve performance impact on how an organisation functions, its structures and the processes of care adopted (Timmers, Hulstaert & Leenen 2014). As hospitals continue to restructure there is limited evidence to support that planned efficiencies and improvements in quality of care are truly realised (Braithwaite et al. 2006; Clemens et al. 2014; Duffield, Kearin, et al. 2007). Indeed post-restructure studies suggest that either no change has occurred or a decline has been observed due to secondary impacts on the workforce and subsequently, patient care (Kjekshus et al. 2014).

Tensions exist between clinicians and administrators due to a perception that organisational performance and efficiency are prioritised over supporting advanced clinical practices, even when directly attributable to better patient outcomes (Carney 2011; Gover & Duxbury 2012). A causal relationship between organisational change at the hospital level and job satisfaction has been established (Sablonnière et al. 2012; Teo et al. 2013). Clinician dissatisfaction is manifested by poorer staff and patient outcomes, and is counterproductive to achieving efficiencies and cost savings (Dodek et al. 2015) .

The nursing workforce represents the largest professional cohort in health and as such is usually subject to efforts to reduce labour costs through organisational restructuring resulting typically with the loss of clinical support positions, increased workload, reduced middle management and increased executive turnover (Duffield, Kearin, et al. 2007; Duffield, Roche, et al. 2011; Moneke & Ogwo 2014). Nurse to patient ratios are often the focus across all acute care settings with ongoing industrial action continuing internationally and in many Australian jurisdictions (Drake 2014; Wallis 2015).

Changes to macro level structural factors due to organisational restructure are thought to be associated with diminished job satisfaction, higher levels of burnout, greater psychological distress, heavier workloads and greater attrition among nursing staff (Burke, Ng & Wolpin 2011; Willem, Buelens & De Jonghe 2007; Zayan, Reizian & Hamouda 2013). For nurses experiencing organisational change the presence of strong effective leaders results in significantly less emotional exhaustion, greater workgroup collaboration and teamwork with physicians, more satisfaction with supervision and their jobs, and fewer unmet patient care needs (Cummings, Hayduk & Estabrooks 2005). Effective interaction between the leadership and employees influences work behaviours, attitudes and team collaboration thereby supporting the objectives of organisational restructuring and ultimately enhancing job satisfaction (Nosrati et al. 2013; Tsai 2011).

In general, medical ICU staff report a higher impact on job satisfaction than nurses when asked about organisational structures (Myhren, Ekeberg & Stokland 2013). Organisational restructure in particular, involving merging and integration of hospital and clinical specialties, is associated with diminished job satisfaction (Mascia, Morandi & Cicchetti 2014). Organisational restructuring is negatively perceived as being a result of organisational politics and increased accountability are key drivers of change.

This Chapter reports on the two separate literature reviews that were conducted to identify outcomes for patients and nurses that are mediated by organisational factors, along with measures of unit level efficiency for use in this research. Each literature review was conducted in three stages. These comprised a standalone scoping evaluation of available review studies and identification of relevant measures, integrative review of empirical studies that had applied the identified measures followed by an evaluation of congruence of the selected measures with clinical and professional practice. Subsequently, the nurse outcomes identified were then used to assess the survey instruments identified in the literature and determine their relevance to this study.

The objective of this approach was to develop a suite of evidence-based outcomes and measures of organisational effectiveness and identify the appropriate instrumentation that together form the basis for evaluating the hot-floor and conventional ICU models. This enabled research question 1) '*What outcome measures, specific to critically ill patients, are mediated by organisational factors?*' and research question 2) '*What outcome measures, specific to ICU nurses, are mediated by organisational factors and what is an appropriate survey instrument?*' to be addressed.

3.2 Patient outcomes and unit level measures

Quality of care is inextricably linked and mediated by clinical practice, organisational management and a skilled workforce (Hariharan & Kumar Dey 2010; Render et al. 2011). Patient outcomes are defined as indicators of change in health status of a patient or a population, ideally casemix adjusted, that result from the process of clinical care and/or the organisational structures for service delivery (Brett 2011; Timmers, Hulstaert & Leenen 2014). Outcome measures in general lack universal and robust risk-adjusted supporting evidence limiting their utility (Duke et al. 2005; Kyeremanteng & D'Egidio 2015).

Heterogeneity of ICU patient populations is known to confound the causal and inferential relationships that may be observed in patient outcome studies of organisational factors, thereby limiting generalisability of findings to the broader ICU patient population (Skinner, Warrillow & Denehy 2015). To mitigate this limitation patient outcome and organisational effectiveness measures, selected for a quality indicator dataset, need to be clinically relevant, evidence based, clearly defined, therapy independent, case-mix adjusted and universally applicable (Braun et al. 2010; Kyeremanteng & D'Egidio 2015; Martinez et al. 2014).

These key requirements underpin the need for an integrative review of the literature (Stage 2) that included a diverse range of research designs and methods in experimental, non-experimental, qualitative and quantitative studies. This broad perspective enriches the understanding of outcomes measurement through the application of a systematic analysis and synthesis to draw conclusions (Cope 2014; Whittemore & Knafl 2005).

3.2.1 Integrative review of patient and unit measures

The review of ICU quality management practices presented in Chapter 2 highlighted the lack of a validated set of patient outcomes known to be associated with organisational factors that can be used to compare different organisational models. Therefore, a three-stage literature review involving an integrative review of available empirical studies (Stage 2) was performed to identify the minimum dataset of patient outcomes and unit level measures for this study (see Figure 3.2).

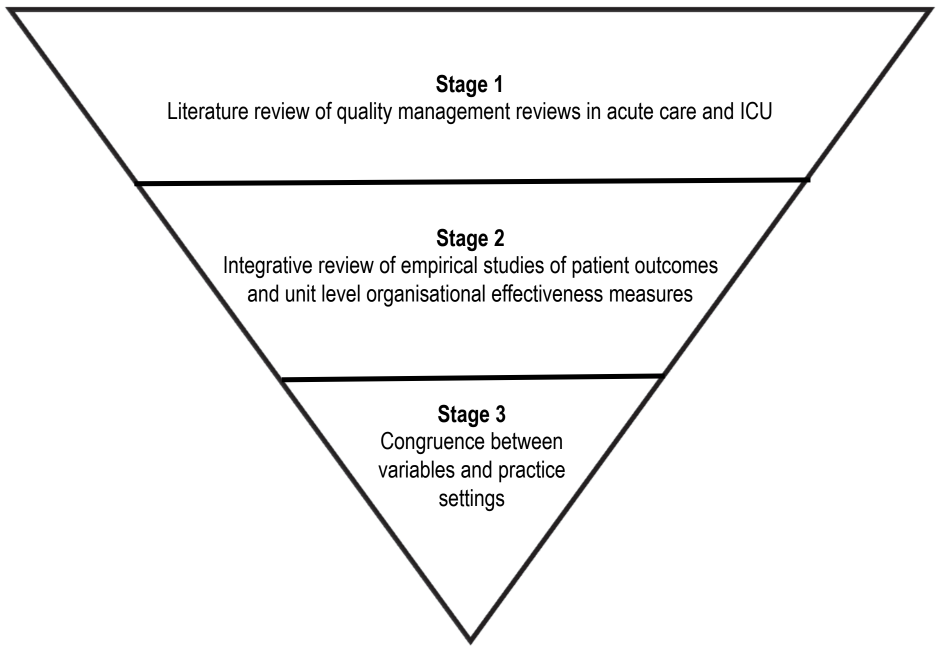


Figure 3.2 Literature review stages for patient and unit level variables

In Stage 1 a scoping review of acute care and ICU quality management reviews was conducted to identify the initial set of measures, or quality indicators, to be evaluated by integrative review of relevant empirical studies then through congruence with accepted clinical practice and standards. Reviews of acute non-intensive care settings were included in recognition of the need to select quality indicators translatable to a broader range of acute care settings. The aim of this approach was to ensure relevance to organisation wide performance assessment and transferability when comparing across services (Burston, Chaboyer & Gillespie 2014; Stalpers et al. 2015a).

Stage 2 used integrative review methodology to explore empirical studies of quality indicators of ICU organisational and structural characteristics identified in the scoping of ICU quality management reviews in Stage 1. The integrative review of evidence pertaining to adult patients receiving critical care sought to identify organisational factors demonstrated to be associated with patient outcomes in both qualitative and quantitative studies. The review searched CINAHL, EMBASE, PubMed and OVID Nursing databases to provide comprehensive coverage of health services management research. Study types explored included cohort, case-control and cross-sectional studies. No randomised controlled trial level evidence was included as these primarily target specific therapies and procedures, and it would be both impractical and not ethically sound to randomise critically ill patients for definitive intensive care for research purposes (Dreyer et al. 2010).

Similarly, individual case reports were not included due to the focus on specific clinical treatments. Editorials and grey literature were not included in the analysis however they were retained to inform the contextual background for the study. Publications from all geographical regions were included, filtered for English language, from peer-reviewed journals.

In Stage 3 quality indicators found to be significant were then compared to those routinely collected or recommended by professional societies and regulatory accreditation agencies e.g. Australian and New Zealand Intensive Care Society and the Australian Council of Healthcare Standards (ACHS 2015; ANZICS CORE 2014b). Congruence with these datasets provided assurance that the measures selected had the operational and clinical relevance required to support generalisation of findings (Render et al. 2011).

3.2.2 ICU quality management reviews

The initial search targeted review papers of studies undertaken within acute and critical care environments, including studies of nurse sensitive outcomes, which were published between 2005 and 2013 inclusive. Increased interest in quality management, particularly in relation to ICU, was evident in the available literature from 2005 with several seminal studies published between 2005 and 2008; hence the extended review period (de Vos et al. 2007; Garland 2005; Stockwell & Slonim 2006; Welch, Harrison & Rowan 2008).

Key search terms included inter-changeable terms used commonly when referring to intensive care used in conjunction with Boolean search symbols i.e. ‘intensive Care unit’ OR ‘ICU’ OR ‘critical care’, searched in all fields. Similarly, interchangeable search terms ‘outcome*’ OR ‘quality’ OR ‘indicator*’ were used in the title search fields targeting primary review studies. The search algorithm used was (‘Intensive Care Unit.af’ OR ‘ICU.af’ OR ‘critical care.af’) AND (‘outcome*.ti’ OR ‘quality.ti’ OR ‘indicator*.ti’). The objective was to identify studies that used quality indicators to evaluate organisational factors, patient outcomes and organisational effectiveness. A total of 136 published review papers were identified of which 106 unique publications were retained for abstract review, following which 87 review studies were retained for full analysis as summarised in Figure 3.3.

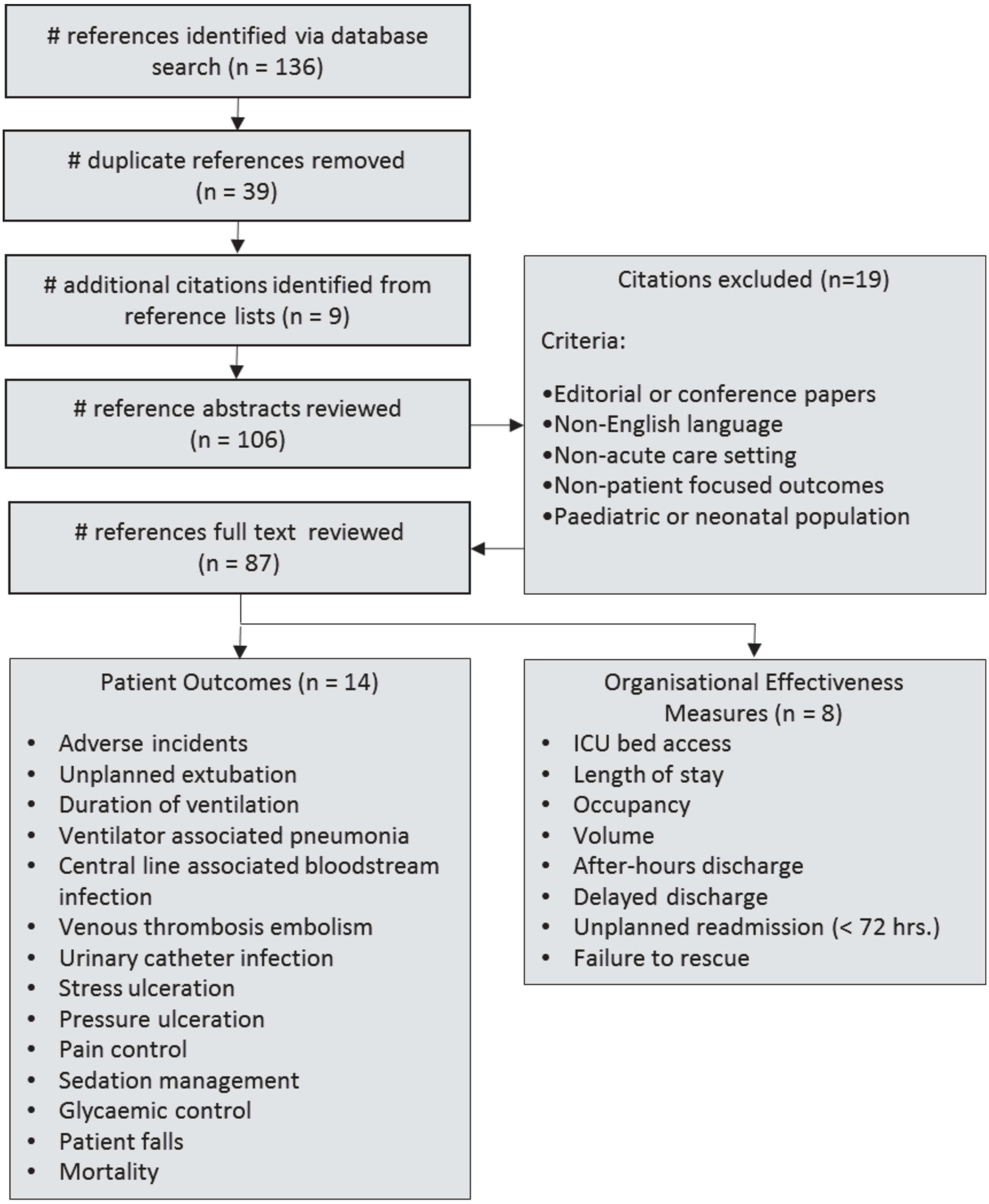


Figure 3.3 Quality management review search summary flow chart

The 87 reviews evaluated (see Appendix 2) included a broad range of narrative, best evidence and systematic reviews of findings from individual studies of patient outcomes that found an association with organisational factors. The literature review rubric developed by Green and Bowser (2006) guided the quality appraisal of the review studies. Overall the reviews provided a clear scope and purpose, included recent and relevant seminal primary studies at the time of the review, and established both the relevance and importance in regard to the association between outcomes and organisational factors studied. Furthermore, relationships between the primary studies evaluated were clearly articulated and a critique of research limitations, including design and methodology, was provided indicating the reviews were good quality (Green & Bowser 2006). The review studies were also broadly distributed across 18 health systems internationally (see Figure 3.4) though primarily concentrated in developed nations including Australia, Canada, the UK and the US.

Figure 3.4 International distribution of quality management review studies

Health system differences limit opportunities for comparing national level indicators, unless regional agreement on standards and definitions has been achieved such as in Western Europe (Flaatten 2012). However, translation and repeatability of variables across multiple countries suggests greater confidence in their validation. Each review study retained was assessed in regard to the variables used, which were then collated into a matrix (see Appendix 2) to determine their frequency as illustrated in Figure 3.5.

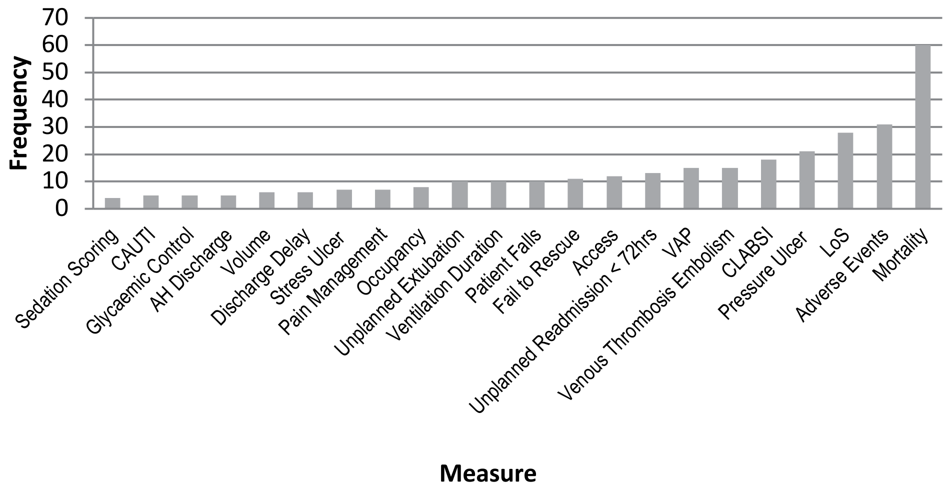


Figure 3.5 Variable frequency of use in quality management review studies

Twenty-two variables, including 14 patient related outcomes and eight unit level measures of organisational effectiveness were identified. A majority of the 22 variables were used in multiple studies with mortality most frequently used in 60 studies while sedation scoring was used in four studies. This reflects the established use of mortality as an evidenced based patient outcome and the more recent adoption of process measures such as sedation scoring, glycaemic control and stress ulcer prophylaxis as clinical best practice (Checkley et al. 2014; Mathioudakis & Golden 2015; Weled et al. 2015).

Mortality is a ‘gold standard’ outcome measure used extensively as a dependent variable to assess the quality of clinical care, organisational factors, management processes (Tourangeau 2011) and as the primary measure in outcome prediction models (Al Tehewy et al. 2010; Higgins, Teres & Nathanson 2008). A significant body of literature supports mortality as a pragmatic outcome measure of quality of care, clinical interventions and technologies (see Figure 3.5 and Appendix 1) (Brand et al. 2013; Doerr & Hekmat 2014), securing its inclusion in this study of hot-floor model. However, despite the extensive use of mortality as an outcome measure it is not recommended as a sole measure of organisationally mediated outcomes and unit level measures of effectiveness (Kyeremanteng & D'Egidio 2015; Lilford & Pronovost 2010; Welch, Harrison & Rowan 2008).

The remaining 21 quality indicators were validated according to study quality and statistical rigour. Five quality indicators, identified in stage one following the initial assessment of review papers, were excluded including adverse events, stress ulceration, pain management, sedation scoring and glycaemic control. Adverse events, as a discrete outcome category, was used in 31 studies and encompassed a broad range of incidents, errors or accidents found to have a causal relationship with patient safety, mortality, morbidity and length of stay (Nilsson et al. 2012; Park et al. 2013). Nine variables identified are either actual, or increase the risk of, an adverse event including unplanned extubation; venous thrombosis embolism prophylaxis (VTEP) compliance; pressure injury; ventilation acquired pneumonia (VAP); central line associated bloodstream infection (CLABSI); catheter associated urinary tract infection (CAUTI); stress ulcer prophylaxis compliance; patient falls and failure to rescue. As such these variables provide surrogate measures of adverse events *per se* therefore 'adverse events' as a discrete outcome category was excluded from further analysis.

Gastrointestinal stress ulceration is considered an adverse event in critically ill patients and is linked to a variety of pathological mechanisms such as low gastric pH, bacterial contamination, hypo-perfusion of the gastric mucosa and the release of pro-inflammatory cytokines in response to physiological stress related to critical illness (Quenot, Thiery & Barbar 2009). Early Studies of patients at risk of stress ulcer-related bleeding indicate there is a benefit from routine prophylaxis, which is regarded by some clinicians as best practice (Penner, Brindley & Jacka 2005). More recent studies, however, question whether routine prophylaxis is still warranted for all ICU patients (Plummer, Blaser & Deane 2014). Furthermore, better haemodynamic management preventing splanchnic ischaemia is increasingly considered a significant contributing factor for the decrease in ulcer development (Barletta et al. 2016).

In terms of clinical compliance with prophylaxis measures, the studies reviewed no linkage was made in any of the studies between compliance process of care protocols for prophylaxis and the standard of ICU care or patient outcomes. Studies compared specific pharmacological therapies with ongoing cause and effect controversy, with no conclusive studies on the impact of compliance. In contrast, compliance with venous thrombosis embolism prophylaxis is supported by a relatively larger body of evidence in the literature (see Figure 3.5) thereby VTEP provides a surrogate measure of prophylaxis compliance in general enabling stress ulceration to be excluded from further analysis.

Similarly, pain management, sedation scoring and glycaemic control in ICU are processes of care driven by clinical protocols. However, studies evaluating these care processes in the literature focus primarily on efficacy of therapies and the scales of assessment utilised (Arbour, Gélinas &

Michaud 2011; Green 2013; Penning et al. 2014). In the quality management reviews evaluated the association between these variables with organisational factors was not evident. It is recognised that quality of clinical care is improved by these care processes, therefore their presence in the study ICUs will be confirmed when site quality management practices are compared to establish service similarities. Pain management, sedation scoring and glycaemic control were thus excluded from further analysis and not included in the variable dataset for this study.

As a result of excluding the five variables and including mortality into the final minimum dataset 16 potential variables were retained (see Table 3.1). This proposed dataset progressed to stage two for integrative review and empirical evaluation.

Table 3.1 Patient and unit level outcome measures for empirical analysis

Category	Measure
Patient Outcome	Unplanned extubation
	Ventilation duration
	Ventilator associated pneumonia
	Central line associated bloodstream infection
	Venous thrombosis embolism prophylaxis
	Catheter associated urinary tract infection
	Pressure injury
	Patient falls
Unit Outcome	Access to an ICU bed
	Length of stay
	Occupancy
	Volume
	After-hours discharge
	Delayed discharge
	Unplanned readmission (to ICU < 72hours)
	Failure to rescue

3.2.3 Integrative review of empirical outcome studies

Empirical studies conducted in ICU between 2008 and 2013 that explored the impact of organisational factors on the 16 quality indicators identified were reviewed in stage two to determine valid outcome measures for use in this study. Key search outcome terms, concepts and the triage of empirical studies are summarised in Table 3.2. Inclusion criteria were studies in English or translated, between years 2008 to 2013 involving the adult patient population. Studies were excluded if an organisational factor was not evaluated, the study was external to ICU, assessed a specific therapy or clinical intervention or diagnostic method, involved neonate or paediatric patients, was diagnosis specific or targeted physiological predictive scoring.

Table 3.2 Literature search summary of empirical ICU outcome studies

Electronic Databases: PubMed, EMBASE, OVID		Variable																	
Search Terms /Concepts	Search (S1 = study 1)	Unplanned extubation	Ventilation duration.	Ventilator associated pneumonia	CLABSI	VTEP	CAUTI	Pressure injury	PF	Access to ICU	Length of stay	Unit occupancy	Volume per bed	After hours discharge	Discharge delay	Unplanned readmission to ICU <72hours	Failure to rescue	Total	
Boolean Symbols: All fields (Af.), Title (ti.), Explode (exp), Truncate (*)	S1	'intensive care' OR ICU OR 'critical care' (all fields)																38,415	
	S2	organisation* OR structure* (title/abstract)																3,710,920	
Filters: Years 2008-2013, Adult, Human, English	S3	outcome* OR indicator* OR measure* (title/abstract)																471,746	
	S4	S1 AND S2																11,038	
	S5	S3 AND S4																10,110	
S6 = S5 AND outcome, measure		35	71	99	130	90	46	38	65	138	84	22	1670	129	124	39	242	3,022	
																		Exc.	Inc.
Excluded on title review[1]		14	63	79	107	78	34	24	61	103	56	9	1576	113	97	14	240	2668	
Excluded on abstract review[2]		9	4	8	6	4	6	9	3	33	4	9	74	9	24	14	2	218	
Empirical studies included		12	4	12	17	8	6	5	1	2	24	4	20	7	3	11	0		**136**

Notes: 1. Review papers and duplicates excluded with relevant titles of empirical studies retained 2. Excluded if (a) organisational factor not explored (b) external to ICU (c) specific to a therapy, protocol/bundle or clinical intervention (d) diagnostic methods (e) neonate, paediatric or diagnosis specific (f) physiological predictive scoring.

A total of 136 quantitative empirical studies were retained for full review and analysis. Studies were aggregated into each of the 16 outcome measure categories to provide the frequency with which each quality indicator was used in the empirical studies reviewed (se Figure 3.6).

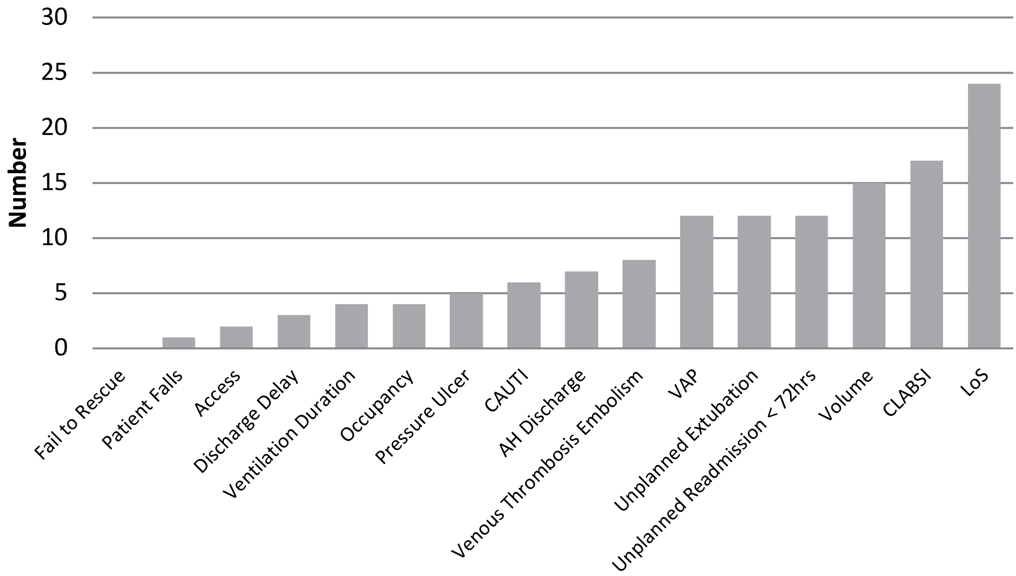


Figure 3.6 Quality indicator frequencies (lowest to highest)

Frequencies ranged from zero (Failure to Rescue) to 24 (Length of Stay) indicating repeatability of each variable across the empirical studies. Repeated testing provided early validation of each quality indicator in regard to inclusion for further analysis (Anthoine et al. 2014).

While an extensive body of literature exists on factors relating to patient deterioration and Failure to Rescue (FTR), studies have been conducted primarily in areas outside of the ICU (Hravnak et al. 2011). Using Failure to Rescue is a controversial measure of organisational effectiveness due to conflicting definitions and multiple confounders that may contribute to the event. Although used as a general indicator of hospital-level performance and quality of nursing care there is little evidence to support using this as a quality or patient outcome measure within the ICU (Blegen et al. 2011). In-hospital medical emergencies involving patient deterioration, unplanned ICU readmissions and unexpected deaths largely result from failure to recognise and respond promptly. Rapid response systems, managed by the ICU, are increasingly being implemented to address this FTR issue (Elmufdi & Weinert 2015). Exploration of associated benefits is extensive as reflected by the number of studies initially identified in this literature review. However, the focus is beyond the 'walls' of the ICU therefore supporting exclusion of FTR as an outcome variable for this study.

As a result, seven patient outcomes and seven unit level effectiveness measures were retained for further analysis commencing with a quality appraisal of the empirical studies for each quality indicator. Methodology underpinning an integrative literature review and the lack of standard definitions for many of the quality indicators did not support the application of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for quality appraisal of the studies reviewed in full (Moher et al. 2015). Study methodology was therefore appraised using criteria contained in the Critical Review of Quantitative Research Worksheet (CRQRW) (Miller 2006).

The CRQRW aligns closely with other well established quality review methodologies including the Quality Assessment Tool for Quantitative Studies (QATQS) and the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines (von Elm et al. 2007). While both appraisal tools have strong psychometric and interrater reliability qualities they were not adopted in favour of CRQRW due to published studies questioning the viability of using solely the STROBE criteria to evaluate the quality of studies and the need for a more thorough broader psychometric evaluation in a range of research fields (Armijo-Olivo et al. 2012; da Costa et al. 2012; Higgins & Green 2008). On review it is evident that CRQRW has much in common with STROBE and QATAS in terms of the items assessed. Based on study quality 15 variables were retained for assessment of statistical validity (see Appendix 3) to elicit the strength of association between each variable and organisational factors in ICU.

3.2.4 Patient outcomes

3.2.4.1 Unplanned extubation

Unplanned extubation, defined as accidental or self-extubation by a patient, represents a potentially serious clinical complication that may compromise a patient's airway, ventilation and may lead to re-intubation of an unstable critically ill patient, and is associated with increased risk of an adverse event occurring. Extubation is usually performed following a planned ventilation-weaning regime with regular clinical assessment to determine suitability. Unplanned extubation is estimated to occur in up to 14% of patients receiving mechanical ventilation (Vianna et al. 2007), negatively impacts morbidity and mortality, and is considered a marker of clinical quality in ICU (Peñuelas, Frutos-Vivar & Esteban 2011). Level of clinical supervision, the staffing model employed, available resources and unit layout are contributing factors (Kiekkas et al. 2013; Selvan et al. 2014).

Initially 40 empirical studies were identified though 28 were excluded due to being therapy specific (16), used in assessing predictive scoring tools (6) or conducted in neonatal or paediatric populations (6). Twelve unequivocal empirical studies identified a significant association between unplanned extubation and organisational factors. Night duty staffing levels was associated with a significant increase in UE (40.3% vs. 63.64%; $p < 0.05$) (Ismaeil et al. 2013), ($X2 = 6.52$; $p < 0.05$) (Cho et al. 2012) and (76% vs. 23.8%; $p = 0.00$) (Chang et al. 2011). Nursing staff workload was also found to predict increased UE (OR 2.26; 95% CI 0.12 – 0.57; $p = 0.001$) (Chen 2012) and ($r = 0.028$; $p = 0.02$) (Liu, Lee, et al. 2012). Inadequate staff training on ETT securement techniques was also implicated in UE ($p < 0.05$) (Thille et al. 2011). Reduced sedation protocol compliance resulted in a higher proportion of unplanned extubation (1.8%; $p < 0.05$) (Agamez, Arnal & Garcia del Valle 2013) with increased odds of this event occurring (OR 15.2; 1.96 – 117.89; $p < 0.01$) (de Groot et al. 2011). Reduced protocol compliance for ventilation weaning ($\beta = 0.66$; $p = 0.02$) (Jarachovic et al. 2011) was implicated in increased odds of extubation (OR 2.69; 95% CI 1.59 – 4.58; $p < 0.001$) (Chen et al. 2010). Increased unplanned extubation was also observed where mechanical restraint protocols were implemented due to staffing that reduced patient supervision ($X2 = 17.06$; $p < 0.001$) (Curry et al. 2008) and ($X2 = 21.79$; $p < 0.001$) (Chang, Wang & Chao 2008).

Of the 12 studies reviewed, nine were observational and three interventional, considered reasonable given the potential safety and ethical issues. Sample sizes ranged from 31 to 1,358 patients with studies primarily single site. Casemix adjustment was used in a majority of studies with small sample sizes and 50% of the studies were prospective enabling better control of confounding. Statistical confidence intervals were provided where appropriate and statistical significance provide in all studies.

Unplanned extubation was associated with organisational factors including staffing, supervision, training and protocol compliance and were therefore retained. Prolongation of ventilation was also associated with the ICU organisational context in regard to staffing ratios, nurse autonomy in decision making, frequency of medical rounds and effective interdisciplinary collaboration (Rose et al. 2008). These factors delay manipulation of ventilation in response to altered physiology, and may hinder recognition of weaning readiness, unnecessarily prolonging ventilation (Blackwood et al. 2011). This review identified 223 studies of ventilation duration and a range of factors including specific medical therapies, clinical protocols, procedures such as tracheostomy, long term ventilation strategies, patient casemix and mortality prediction. Only four empirical studies of ventilation duration and organisational factors were identified of which two explored staffing and workload, and two evaluated team structure and communication.

Conflicting results were found in relation to workload with increased duration associated with higher patient ratios (OR 0.4; 95% CI 0.1 – 1.0; $p < 0.05$) (Rose et al. 2011) but reduced in high intensity settings (HR 1.66; 95% CI 1.18 – 2.32); $p = 0.04$) (Singer et al. 2010). Effective multidisciplinary team communication was associated with a reduction in ventilation duration (mean hours. - 0.83; 95% CI - 1.86 – 0.20; $p < 0.01$) (White, Currey & Botti 2011), although a non-significant association was reported in a large multicentre study of 25,552 patients (HR 0.94; 95% CI 0.76 – 1.15; $p > 0.05$) (van der Veer et al. 2013). The small number of empirical studies, conflicting results and high confounding risk resulted in this variable being excluded for the current study.

3.2.4.2 Ventilator associated pneumonia

Ventilator associated pneumonia (VAP) is defined as the diagnosis of pneumonia occurring after mechanical ventilation is initiated, usually 48 hours or more after tracheal intubation (DHHS 2009; Kalil et al. 2016) and accounts for approximately half of all antibiotics given in ICU (Hunter 2012). The mechanism leading to VAP is related to the presence of an endotracheal tube that prevents effective coughing and encourages micro-aspiration of contaminated pharyngeal contents and is the most common nosocomial infection in ICU (Hunter 2012). This review identified 202 studies specific therapies, diagnosis methods, environmental factors, mortality prediction and extensive clinician debate regarding the definition of VAP. Twelve empirical studies explored VAP rates in relation to organisational factors including training, protocol compliance, workload and team structures in ICU. Two of five training program studies were not significant (Bingham et al. 2010; Kahn, Ten Have & Iwashyna 2009). Improved VAP bundle compliance was associated with a local education program ($t = 21.41$; $p < 0.001$) (Subramanian et al. 2013) while a reduction in the VAP rate from 6.01 to 1.91 VAP/1.000 ventilator days ($p < 0.05$) (Raurell Torreda 2011) and a reduction in VAP incidence (IR 0.51; 95% CI 0.41 – 0.64; $p < 0.05$) (Berenholtz et al. 2011) were also observed. Reductions were also identified in five studies of protocol compliance and the use of process checklists. The largest study of 27,125 patients retrospectively evaluated implementation of process checklists finding a significant reduction in VAP rates ($\bar{x}$ = 176 vs. 56; $p < 0.001$) (Lim et al. 2013). Increased staff workload from one patient to one nurse, to two patients per nurse was implicated in increased VAP incidence (9.35% vs. 25.7%; $p = 0.003$) (Blot et al. 2011). Lastly, the impact of structured multidisciplinary rounds was also found to significantly decrease the ratio of VAPs per thousand ventilator days from 34.4 to 23.4 ($p = 0.04$) (Johnson et al. 2009).

In terms of study quality four studies involved a prospective intervention and two were prospective observation studies, while the remaining six were retrospective and evenly split between intervention and observation studies. Large sample sizes ranged from 71 to 550,800 patients with five studies employing case mix adjustment and two had a multicentre scope. Despite the significant associations found between VAP reduction and a variety of ICU organisational factors and satisfactory study quality the clinical definition of VAP was repeatedly identified as a potential confounder. The current definition of VAP is constructed from nonspecific clinical signs common to many complications of critical care with the lack of a 'gold standard' definition leading to both under and over diagnosis (Klompas, Kulldorff & Platt 2008; Wallace et al. 2015). Due to ongoing contemporary debate regarding the definition of VAP any inference that VAP rates might be associated with organisational factors cannot be confidently made (Klompas & Berra 2016). Therefore, VAP was excluded as a variable in the current study.

3.2.4.3 Central line associated bloodstream infection

Central Line Associated Bloodstream Infection (CLABSI), due to contamination during insertion or management of a central venous catheter, is responsible for 20-40% of healthcare-associated bloodstream infections in Australia and poses a threat to critically ill patients globally (ACHS 2009; Latif, Halim & Pronovost 2015). Risks differ amongst clinical units due to the type of device used and intrinsic patient factors, though a significant proportion of CLABSI events are preventable through best practice (Seddon et al. 2011). Prevention programs such as the Central Line Associated Bacteraemia project in NSW Intensive Care Units Collaborative had a significant impact through improved compliance with aseptic insertion ($p <0.001$) reducing the CLABSI rate from 3.0 to 1.2 per 1000 line-days ($p <0.001$) (Burrell et al. 2011). Extensive evidence also exists on the impact CLABSI has on increased length of stay, mortality and costs in ICU (Barnett et al. 2010; Mclaws & Burrell 2011; Zack 2008).

This review initially identified 142 studies but a majority were excluded due to being therapy specific, targeting specific diagnosis categories, conducted in a paediatric or neonatal context or focused on CLABSI surveillance. Of the 17 empirical studies retained 11 found a significant association between reduced CLABSI rates and improved protocol compliance. The largest international study prospectively explored 501,296 central venous line days across 192 ICUs finding a significant CLABSI risk reduction (RR 50%; 95% CI 0.39 – 0.63; $p < 0.001$) (Palomar et al. 2013). Four studies evaluating education programs consistently demonstrated significant CLABSI reduction including staff credentialing which reduced the number of CLABSI per month from 16.0 to 10.0 ($p = 0.012$)(Cherry et al. 2011) and staff feedback sessions leading to a reduced risk of CLABSI (RR 0.46; 95% CI 0.33 – 0.63; $p < 0.001$) (Rosenthal et al. 2010). Strong nurse leadership was found to increase protocol compliance to 100%, though the statistical significance of the association on reduced CLABSI was not specified (Richardson & Tjoelker 2012). In an early multicentre study of 2,970 patients the number of ICU beds was found to influence CLABSI rates with a reduction of 3% ($p < 0.05$) per additional bed observed attributed to a higher volume of procedures undertaken and clinician protocol compliance (Kritchevsky et al. 2008).

A majority of the studies were multicentre prospective intervention evaluations with large sample sizes ranging from 368 to 10,890 central line insertions or 6,868 to 501,296 central line days improving control for confounders. A large casemix adjusted randomised controlled trial across 45 ICUs in the US enhanced the quality of the evidence finding unequivocal association between staff education and reduced risk of CLABSI (IR 0.19; 95% CI 0.06 – 0.57; $p = 0.003$) (Marsteller et al. 2012). Throughout the broader available literature CLABSI rates are recommended as a measure of organisational, operational and clinical factors that contribute to ICU performance (Hebden 2015; Sagana & Hyzy 2013), supporting inclusion in the current study.

3.2.4.4 Venous thrombosis embolism

Venous Thrombosis Embolism Prophylaxis (VTEP) is a potentially avoidable cause of morbidity and mortality in critically ill patients, with 85% at risk of VTE without prophylaxis and estimates of hospital acquired VTE between 10–20% (Geerts 2008; Mokhtari et al. 2014). Clinical evidence indicates that VTEP is best practice (Bergmann 2010; Grant & Flanders 2015). The proportion of patients receiving VTEP within 24 hours of admission to Australian ICUs is a mandatory quality indicator (ACHS 2014). Initially 61 studies were reviewed with 53 excluded due to being therapy specific, surveillance review studies and/or targeted diagnostic groups such as severe trauma.

Eight empirical studies were retained in regard to VTEP protocol compliance and the association with education and safety programs, staffing and occupancy, and structured multi-disciplinary clinical rounds. Of the four education and safety intervention studies one Australian study of 576 staff demonstrated a 19% improvement in compliance ($p = 0.002$) (Duff, Walker & Omari 2011). This significant improvement was repeatedly observed in diverse study contexts in US, Saudi Arabia and Italy respectively (Al Tawfiq & Saadeh 2011; Boddi et al. 2010; Kahn et al. 2010). In a large retrospective international study of 227,286 patients high ICU occupancy was observed to compound capacity strain thereby reducing VTEP compliance (OR 0.98; 95% CI 0.97 – 0.98; $p < 0.05$) (Weissman et al. 2015).

Reduction in compliance was also observed where the staff were more junior (82%; $p = 0.001$) (Dabbagh et al. 2009). Multi-disciplinary rounds involving an ICU Pharmacist were introduced to reduce non-compliance with VTEP (RR 0.89; 95% CI 0.79 – 0.99; $p < 0.05$) (Morris, Forrest & Campbell 2010).

Five studies were prospective intervention studies and the remainder retrospective observational studies. Only one study employed casemix adjustment though confounding was controlled through large sample sizes with 50% of studies involving multiple ICUs. The eight studies explored the impact of organisational factors on the adoption of best practice initiatives and compliance with VTEP, which is regarded in the broader literature as a reliable ICU quality indicator (Boddi et al. 2014). Based upon this assessment compliance with VTEP was included as a variable for this current study.

3.2.4.5 Catheter associated urinary tract infection

Catheter Associated Urinary Tract Infection (CAUTI) is a common nosocomial infection in ICU associated with high antimicrobial use resulting in the urinary tract becoming a suitable reservoir for antimicrobial-resistant pathogens that may cause other more serious infections (Chant et al. 2011). Increased mortality and length of stay have been reportedly associated with CAUTI in ICU patients in unadjusted analysis although, following adjustment for other prognostic factors, CAUTI no longer had a significant influence (Chant et al. 2011).

This review identified 61 studies of which a majority targeted specific therapies, antimicrobial resistance, urinary drainage devices, casemix and surveillance. Six empirical studies were retained with four of the five prospective interventional studies reporting a significant reduction in CAUTI rates due to safety programs, the largest being a multi-centre study of 56,429 patients confirming reduced risk of infection (RR 0.63; 95% CI 0.55 – 0.72; $p < 0.05$) (Rosenthal et al. 2012). One observational study of ICU size found ICUs in hospitals with ≥ 500 beds were half as likely as those in smaller hospitals to have adopted at least one CAUTI prevention policy due to less direct access to the infection control service (OR 0.52; 95% CI 0.33-0.86; $p < 0.05$) (Conway et al. 2012). However, the literature indicates that like VAP, CAUTI suffers from definitional issues impacting on accurate diagnosis and surveillance (Leblebicioglu et al. 2013; Talaat et al. 2010). Based on the limited empirical evidence and controversies over definition this variable was excluded for the current study.

3.2.4.6 Pressure injury

Pressure injury, due to unrelieved compression particularly over bony prominences, causes tissue damage and is prevalent in patients with restricted mobility, poor nutrition and pathophysiological conditions (O'Meara & Nagarsheth 2015). Risk of injury in critically ill patients is high with serious untoward patient and health system outcomes (Shahin, Dassen & Halfens 2009). Prevention is an important safety and quality improvement priority (Elliott, McKinley & Fox 2008). While the patient’s clinical and pathophysiological condition are key determinants, pressure injury in ICU has been linked to compliance with evidence-based protocols, an organisational culture of safety and workload (Bredesen et al. 2015; Loan, Patrician & McCarthy 2011; Stone et al. 2007).

Out of 88 studies identified in the literature five empirical studies of organisational factors were reviewed of which four revealed a significant reduction in the incidence of pressure injury associated with structured nursing rounds of 50% ($p < 0.05$) (Kelleher, Moorer & Makic 2012) and increased staff seniority ($X^2 = 41\%$; $p = 0.019$) (Strand & Lindgren 2010). The odds of sustaining an injury was reduced by a targeted education program (OR 0.40; 95% CI 0.26 – 0.62; $p < 0.01$) (Anguera Saperas et al. 2009) and the prevalence decreased from 50% to 8% ($p < 0.05$) following an ICU safety program that increased in the use of pressure-relieving devices from 75% up to 95% ($p < 0.05$) (Elliott, McKinley & Fox 2008). A 4% reduction was observed in relation to higher nurse workload ($p = 0.015$) (Cremasco et al. 2013). Two studies involved prospective interventions and two prospective observational studies had sample sizes ranging from 146 to 563 patients with casemix adjustment. Lastly, protocols for pressure injury assessment, grading and risk management were supported by a large body of clinical evidence reducing subjectivity of assessment (Soh, Soh & Davidson 2013). Evidence based standardised care and large high quality studies that use casemix adjustment supported the inclusion of pressure injury in the current study.

3.2.4.7 Falls

Patient falls in acute care areas of tertiary hospitals are an important quality and safety issue with rates ranging from 2% to 5% (Patman, Dennis & Hill 2011). Factors increasing risk of falling include advanced age, altered mental status, medications that act on the central nervous system and poor mobility. These characteristics are common to ICU survivors who may be at increased risk of suffering a fall following transfer from ICU.

However, patients in ICU are typically bed or chair bound, and if mobilised assisted by a clinical team and under constant observation due to staffing ratios, therefore patient falls in the ICU are rare. This was reinforced by the 65 studies identified in which the focus was on falls occurring post-transfer outside the ICU environment. No empirical studies on the association of falls and ICU organisational factors were evident in the published literature. Primarily studies involved the reviews of nurse sensitive outcomes in ward areas where patients mobilise independently (Hart & Davis 2011; Stalpers et al. 2015a) therefore patient falls were not included in the current study.

3.2.5 Unit level measures

3.2.5.1 Access

Access to ICU is a measure of organisational effectiveness that reflects triage processes, patient throughput, operational contingency, efficient demand management, resource utilisation, and staffing factors (Braun et al. 2010; Duke et al. 2005; Terblanche & Adhikari 2006). Large multispecialty ICUs are assumed to provide greater operational flexibility, despite higher activity, to better manage unplanned and seasonal surges in demand (Iapichino et al. 2005; Jones 2010; Kim et al. 2000; Xiao et al. 2010).

Access to an ICU bed can be measured by the time taken for unplanned and planned admissions to access an ICU bed and reflects the quality of the ICU management and organisational structure, which in turn, may impact on patient mortality and length of stay (Cardoso et al. 2011; Shorr, Choe & Linde-Zwirble 2011). Each hour delay has been associated with a 1.5% increase in mortality (HR: 1.015; 95% CI 1.006 to 1.023; $p = 0.001$) (Cardoso et al. 2011), with an eight hour delay resulting in a greater odds of death (OR, 1.44; 95%; CI 1.26-1.64; $p < 0.01$) (Liu, Kipnis, et al. 2012) . Conversely, direct admission reduced mortality significantly (OR: 0.73; 95% CI 0.62–0.87; $p < 0.0001$) (Iapichino et al. 2010).

Initially 35 studies were retained for abstract review of which the majority were excluded as they examined access in relation to clinician triage decisions, geographical and seasonal characteristics. One retrospective observational study found no association between the time of day for ICU admission and mortality (HR 1.10; 95% CI 0.94-1.28; $p = 0.24$) (Bisbal et al. 2012). A prospective interventional study identified a significant reduction in time to access an ICU bed for Emergency Department patients due to proactive bed management strategies (-28% access time; < p 0.001) (Howell et al. 2010). Both studies had large sample sizes ranging from 1,716 to 3,540 patients, though only the prospective interventional study was casemix adjusted (Howell et al. 2010).

Based upon the limited equivocal evidence available, ICU access time at the individual patient level was not included as a variable in the study. However, an aggregate unit level measure of access, reported to the ANZICS APD bi-annually, will be used to compare study settings and with the reported national average for Australian tertiary ICUs.

3.2.5.2 Length of stay

Length of stay is well established as an indicator of clinical quality and organisational effectiveness in ICU (Kastrup et al. 2009; Wagner et al. 2013). Influential organisational factors include team structures, staffing and workload, management of patient throughput, evidence based practice compliance and process quality initiatives (Verburg et al. 2018). Of the 24 empirical studies reviewed 14 were prospective, including five randomised controlled trials (RCTs), 12 of which involved an organisational intervention. The remaining ten studies were retrospective with three being a post intervention evaluation. Six studies were multicentre with sample sizes for all studies ranging from small RCTs of 20 to 36 patients up to a large observational study of 1,330,484 patients (Lipitz-Snyderman et al. 2011). Twenty studies applied case mix adjustment and broad range of study settings were represented internationally including Australia, Brazil, Canada, China, Europe and the US.

A statistically significant length of stay reduction was observed in 18 studies. Team structures and communication were related to decreased length of stay in six of eight studies involving multidisciplinary rounds ($\beta = -0.07$; $p = 0.01$) (Pacheco et al. 2011), presence of a clinical psychologist (X2 = - 4.2; $p < 0.022$) (Szilagyi, Dioszeghy & Varga 2008) and involvement of a palliative care team (7 vs. 11 days; $p < 0.001$) (Walker et al. 2013). The use of telemedicine during word rounds to support communication was found to reduce patient length of stay in three studies, one of which was a large casemix adjusted prospective intervention study of 2,217 patients that found a 58% reduction in ICU length of stay ($p < 0.05$) (McNelis, Schwall & Collins 2012).

Of eight staffing and workload studies, six demonstrated a significant reduction in length of stay with improved medical staffing on night shift a significant factor. As an example, a large casemix adjusted prospective intervention study of 3,803 patients found a reduction from 4.8 days to 3.5 days ($\bar{x}$ = - 23%; $p < 0.05$) (Banerjee et al. 2011). Increased nurse workload, reflected by a Nursing Activities Score of greater than 66.4%, increases length of stay ($\bar{x}$ = 31%; $p = 0.015$) (Padilha et al. 2008). In contrast, reduced length of stay is associated with increased staffing intensity ($\bar{x}$ = 4.46 vs. 2.63 days; $p < 0.05$) (Hawari et al. 2009). Emergency Department admissions were found to have an increased length of stay in three studies, one a large retrospective casemix adjusted study of 3,257 patients (OR 2.87; 95% CI 1.27 – 6.51; $p < 0.05$)

(Zampieri et al. 2013) and another a study of 2,598 patients (OR 1.93; 95% CI 1.46 – 2.54; $p < 0.05$) (Huang et al. 2010). Three of four studies found that protocol compliance reduced length of stay due to lower rates of CLABSI ($\bar{x}$ = 3.1; 95% CI 3.2 – 87.7; $p < 0.05$), VAP ($\bar{x}$ = 8.6; 95% CI 6.4 56.9; $p < 0.05$) and CAUTI ($\bar{x}$ = 8.1; 95% CI 4.5 – 132.6; $p < 0.05$) (Kubler et al. 2012). Additionally, nurse initiated extubation protocols also reduced length of stay in ICU ($\bar{x}$ = - 29% days; $p = 0.01$) (Danckers et al. 2013). Demonstrated association with organisational factors and the high quality of the studies reviewed supported inclusion of patient length of stay in the current study.

3.2.5.3 Unit occupancy

Unit occupancy is a product of ICU utilisation, patient throughput including exit block, operational flexibility and responsiveness to the demand, and bed capacity (Reddy et al. 2015). High volume ICUs with high occupancy have been implicated in worsening patient outcomes (Halpern 2011; Howell 2011; Zimmerman 2009) due to increased hospital acquired infections, unplanned re-admissions and mortality (Chrusch et al. 2009; Iwashyna, Kramer & Kahn 2009; Kong et al. 2011).

Of the 22 empirical studies identified four were retained following abstract review as they dealt directly with unit occupancy as a measure of organisational effectiveness in terms of infection rates, readmission rates and mortality. While only four were retained they demonstrated high quality, with sample sizes ranging from 600 to over 200,000 patients and a majority multicentre studies with case mix adjustment.

High ICU occupancy was found to increase refusal of admission at first referral, leading to access delay and higher mortality rates on day 28 ($p = 0.05$) and day 60 ($p = 0.04$) when compared with directly admitted patients (Robert et al. 2012). A peak occupancy level increased unadjusted mortality (f = -2.57; 95% CI -3.09 to – 2.06; $p < 0.001$) (Iwashyna, Kramer & Kahn 2009) but not significantly after casemix adjustment. Premature discharge, usually after-hours, increased during high occupancy, significantly increased the risk of unplanned readmission (RR = 1.56; 95% CI 1.05- 2.31; $p < 0.001$) (Chrusch et al. 2009). Increased infection rates of 0.009 new acquisitions per patient per day ($p < 0.05$) (Howie & Ridley 2008) were observed. Unit occupancy is an influential variable for organisational effectiveness in terms of demand management and is linked to patient outcomes (Iapichino et al. 2004; Iwashyna, Kramer & Kahn 2009) and was therefore included in the current study.

3.2.5.4 Annual patient volume

Critical care service regionalisation results in large capacity units with typically high patient throughput and volumes, although the impact of this is not well-understood and not consistent across diagnostic groups (Abbenbroek, Duffield & Elliott 2014a; de Lange, Wunsch & Kesecioglu 2015). The volume versus mortality relationship has been investigated concluding that complex critically ill patients, such as those with sepsis and ventilation, benefit most in high volume ICUs with a reasonable occupancy rate (Kahn et al. 2006; Peelen et al. 2007; Walkey & Wiener 2014). A large flexible ICU bed base supported by broader staffing ratios may better manage high patient volumes while reducing after-hours discharge due to resource constraints and the risk of an adverse event (Iapichino et al. 2005; Lin, Chaboyer & Wallis 2009).

Evidence supporting outcomes improvement and high ICU volume has long been regarded as controversial due to patient heterogeneity and inconsistent definitions of volume (Durairaj et al. 2005; Kanhere et al. 2012) providing the impetus for an integrative literature review of the phenomenon as part of this thesis (Abbenbroek, Duffield & Elliott 2014a). In summary, the review included 20 quantitative observational studies that were primarily retrospective with three prospective. Nine studied mechanically ventilated patients, six included all admissions to ICU, three reported on patients with sepsis and one study each on patients post cardiac arrest and those receiving renal replacement therapy. Sixteen studies reported a significant association between lower risk adjusted mortality and higher-volume units supporting volume being included as a study variable to be assessed.

3.2.5.5 After-hours discharge

After-hours ICU discharge refers to those patients transferred between 6pm and 6am and is attributed to unit high occupancy, volume and demand often leading to premature discharge to admit more acute critically ill (Brasel 2008). Patients transferred after-hours frequently become outliers in inappropriate wards and at a time when staffing, resources and expertise are limited increasing the risk of deterioration (Singh et al. 2010), unplanned readmission and poor outcomes including mortality (Barker & Flint 2010; Laupland et al. 2008 ; Pilcher et al. 2007). Like volume, the evidence has long been controversial with a recent prospective multicentre study of 40 ICUs in Australia and New Zealand, concluding that the time of discharge was not associated with mortality (Santamaria et al. 2015).

This review identified 129 empirical studies from which 122 were excluded following abstract review due to the focus being on inter-ICU transfers, predictive physiological scores, specific patient diagnosis, surveillance and paediatric patients. Seven observational studies were retained, including six retrospective and one prospective, all case mix adjusted with large samples ranging from 1,050 to 17,864 in international studies across multiple ICUs.

Similar to earlier research, after-hours discharge results from organisational barriers caused by peak occupancy, unplanned demand and limited operational flexibility, with mortality the primary outcome variable. Exemplifying this relationship was an Australian prospective study of 10,211 patients from 40 ICUs that confirmed increased odds of mortality (OR 1.47; 95% CI 1.05 – 2.05; $p < 0.05$) (Santamaria et al. 2011). Two studies found increased odds of unplanned ICU readmission attributed to night discharge (OR 2.75; 95% CI 1.7 – 4.3; $p < 0.001$) (Gopal, Terry & Corbett 2010) and (12.2% vs. 9.0%; $p = 0.027$) (Hanane et al. 2008). The relationship of these outcomes with organisational factors supported inclusion of after-hours discharge in the current study.

3.2.5.6 Discharge delay (exit block)

Timely discharge from ICU is subject to effective communication, individual patient factors and teamwork both internal and external to the unit (Lin, Chaboyer & Wallis 2009). Delayed transfer of a discharge-ready patient to the receiving ward can be measured as time from bed request to physical departure or as the proportion of transfers exceeding a pre-determined time threshold. Discharge delay from ICU is a whole of hospital phenomenon caused by multiple external organisational factors including access to appropriate hospital beds, for example single rooms for infectious patients, and adequate staffing (Lin et al. 2013).

High hospital bed census is positively correlated with ICU discharge delay (Spearman rho = 0.27; P < 0.0001) (Johnson et al. 2013) attributed to limited organisational control of hospital demand, acuity and complexity. Effective clinical service provision may reduce hospital length of stay and improve ward bed availability (Mallor, Azcárate & Barado 2015) to avoid a backlog of patients, impeding ICU access and adversely affecting outcomes (Okuda et al. 2014; Williams et al. 2010).

Evaluating the cause and impact of discharge delay is challenging due to varying definitions of discharge request time and 'exit' block, or delay, thresholds which is commonly suggested to be six hours (Peltonen et al. 2015). Of the 27 identified 27 studies, 24 were excluded due to the focus being on predictive physiological tools and scores and specific diagnosis categories. Two prospective studies and one retrospective study were retained, all observational and case mix adjusted with large samples of 731 to 2,401 ICU patients. Delayed discharge compounded after-hours transfers 21% vs. 12% (patients not delayed) (X^2 = 10.6; $p < 0.05$) (Johnson et al. 2013). A study of 2,401 patients found discharge delay associated with increased mortality at 30-days with a U-shaped relationship observed with the nadir at 20 hours ($p = 0.002$) (Garland & Connors 2013). An Australian study found a 6% increase in delays greater than 8 hours (53%; $p < 0.001$) could be attributed to restricted hospital bed availability (Williams et al. 2010).

While available empirical evidence was limited, reference was made to the importance of operational flexibility in ICU to respond to demand and manage patient throughput effectively in the presence of external hospital wide uncontrolled factors (Debajyoti, Leed & Thomas 2008; Iapichino et al. 2005; Town et al. 2014). Operational flexibility is an assumed benefit of the hot-floor model warranting the inclusion of discharge delay in the current study.

3.2.5.7 Unplanned readmissions to ICU

Lastly, unplanned readmissions, defined as an ICU readmission within 72 hours of discharge from ICU (ACHS 2013), were evaluated. Australian unplanned readmission rates are estimated to be 4-5% (ANZICS CORE 2014a) and associated with increased length of stay and mortality (Araujo et al. 2013; Chan et al. 2009).

Contributing factors are largely outside of ICU control and primarily related to the level of observation and care received in wards particularly when patients are clinical 'outliers' in wards with inappropriately trained clinical staff and a lack of clinical support services (Diya et al. 2012; Elliott, Worrall-Carter & Page 2014). This review initially yielded 39 studies of which 28 were excluded due to a focus on predictive physiological tools and scores, specific patient diagnosis categories, staff perceptions and surveillance. Eleven retained studies included four prospective and seven retrospective observational studies, seven were case mix adjusted and all had large samples between 1,050 to 192,202 patients.

3.2.6 Interim patient outcome and unit level variables

In summary, the studies found ICU staffing, structural factors and the management of patient throughput to influence unplanned readmissions. Reduced nurse workload due to lower patient volume resulted in fewer unplanned readmissions ($\bar{x}$ = - 0.46; 95% CI -0.84 - 0.09; p = 0.05) (Diya et al. 2012) as did lower patient dependency as measured by the Nursing Activity Score (OR 0.98; 95% CI 0.95 – 1.00; p = 0.04) (Silva, Sousa & Padilha 2011). Six studies found elements of patient throughput including ICU admission source, premature and time of discharge increased unplanned readmissions. One multicentre study of 13,598 Australian ICU patients reported, exemplified the relationship between these factors and increased unplanned readmission rates associated with after-hours discharge (OR 1.13; 95% CI 1.08 – 1.19; $p < 0.001$) and increased unwarranted length of stay in ICU (OR 1.017; 95% CI 1.015 – 1.019; $p < 0.001$) (Renton et al. 2011). While three studies observed higher readmission rates for tertiary level ICUs (OR 1.51; 95% CI 1.12 – 2.02; $p < 0.05$) (Brown et al. 2012), peak unit occupancy (OR 1.56; 95% CI 1.05 – 2.31; $p < 0.05$) (Chrusch et al. 2009) and high patient volume (OR 2.34; 95% CI 1.27 – 4.34; p < 0.05) (Baker et al. 2009).

It is important to recognise that unplanned readmissions to ICU can be affected by a multitude of external organisational factors such as ward staffing and the availability of beds in an appropriate speciality ward. Evidence yielder from this review supported the retention unplanned readmission as a study variable, therefore the interpretation of findings in regard to ICU organisational factors needs to be cognisant of the potential for confounding identified statistical associations relationships.

The integrative review resulted in the dataset being distilled from 22 to 12 variables (see Table 3.3) and encapsulate the spectrum of service delivery to evaluate the organisation of ICU (Whittle & Shelton 2012). Further validation of the dataset in terms of contextual relevance was then undertaken through the assessment of the level of congruence the selected variables had with existing administrative and clinical registries.

Table 3.3 Patient and unit variables identified through stage one and stage two

	Variables		Evaluation	
#	Type	Measure	Assessment	Determination
1	Patient	Adverse events	Captured by UE	Proxy
2	Patient	Unplanned extubation	√	Include
3	Patient	Ventilation duration	Confounded evidence	Exclude
4	Patient	VAP	Definitional issues	Exclude
5	Patient	CLABSI	√	Include
6	Patient	VTEP	√	Include
7	Patient	CAUTI	Insufficient ICU evidence	Exclude
8	Patient	Stress ulcer prophylaxis	Care Process	Exclude
9	Patient	Pressure injury	√	Include
10	Patient	Pain management	Care Process	Exclude
11	Patient	Sedation management	Care Process	Exclude
12	Patient	Glucose control	Care Process	Exclude
13	Patient	Patient falls	Insufficient ICU evidence	Exclude
14	Patient	Mortality	√	Include
15	Organisational	Access an ICU bed	√	Include
16	Organisational	Length of stay	√	Include
17	Organisational	Occupancy	√	Include
18	Organisational	Volume	√	Include
19	Organisational	After-hours discharge	√	Include
20	Organisational	Delayed discharge	√	Include
21	Organisational	Unplanned readmission	√	Include
22	Organisational	Fail to rescue	Insufficient ICU evidence	Exclude

3.2.7 Variable congruence with the clinical environment

The minimum dataset of 12 outcomes was compared to existing Australian and international ICU clinical registries, and regulatory agency collections to gauge their clinical and professional relevance (Render et al. 2011) (see Table 3.4). All 12 measures were either collected or recommended internally to be collected at the local level and at state, national and international levels, upholding the clinical and professional relevance of the measures selected. The minimum dataset also fulfils the requirements of structure, process and outcome quality domains that underpin quality management in ICU, in turn enhancing meaningfulness and generalisability of any subsequent findings (Brett 2011; Dodek, Keenan, Norena, Martin, et al. 2010; Moreno, Bauer & Metnitz 2010).

Table 3.4 Congruence of patient and unit level variables

	Variable (√) Collected	Type	Hospital[1]	State[2]	ACHS[3]	CICM[4]	ANZICS [5]	ICNARC[6]	ESICM[7]	SCCM[8]	Study Data Source
1	Unplanned Extubation	Patient	√	R		R	R		R		ICU
2	CLABSI	Patient	√	R	√	R	√	√	R	R	ICU/APD
3	VTE Prophylaxis	Patient	√	R	√	R	√		R	R	ICU/APD
4	Pressure Ulceration	Patient	√	R	√						ICU
5	Mortality	Patient	√	√		R	√	√	R	R	ICU/APD
6	Access an ICU Bed	Organisational	√	R	√	R	√	√	R	R	ICU/ACHS
7	Length of Stay	Organisational	√	√		R	√	√			ICU/APD
8	Occupancy	Organisational	√	√		R	√	√			ICU/APD
9	Volume (Activity)	Organisational	√	√		R	√	√			ICU/APD
10	After-Hours Discharge	Organisational	√	√	√	R	√	√	R	R	ICU/APD
11	Delayed Discharge	Organisational	√	R	√	R	√	√	R	R	ICU/APD
12	Unplanned Readmission	Organisational	√	R	√	R	√	√	R	R	ICU/APD

Notes:
1. Locally collected by the ICU for internal quality management
2. NSW Ministry of Health, Bureau of Health Information
3. Australian Council of Health Care Standards
4. College of Critical Care Medicine
5. Australia and New Zealand Intensive Care Society (Australian Patient Database)
6. Intensive Care National Audit and Research Centre (United Kingdom)
7. European Society of Intensive Care Medicine
8. Society of Critical Care Medicine

(R) Recommend collection

3.3 Nurse outcomes

A second literature review was performed, including a first stage integrative review of primary studies, to identify empirically validated nurse outcomes that are mediated by organisational factors in the ICU workplace. This process was the first step in determining appropriate survey instrumentation for the study to assess the impact of organisational factors, such as structural characteristics and operational management processes, on the nursing workforce (Chan & Huak 2004; Klopper et al. 2012).

A positive workplace is a setting where policies, procedures and systems achieve organisational objectives and promote staff satisfaction (Shirey 2009). Healthy work environment attributes have been identified by the International Council of Nurses (ICN 2010), American Association of Critical Care Nurses (AACN 2016) and in Canada (Ontario Health 2010), with recommended organisational qualities for positive outcomes validated in Australian nursing workforce studies (Duffield, Roche, et al. 2007; Walker, Fitzgerald & Duff 2014). Affirmative work environments positively influence job satisfaction, staff retention and nurse outcomes (Ritter 2011).

Key attributes including strong leadership, effective communication, autonomous collegial relationships, appropriate staffing and provision of high quality care are particularly important in ICU (Klopper et al. 2012). High staffing levels and resource inputs, complex clinical activity at the point of care, combined with elevated emotional stress typifies the ICU work environment, providing an opportunity to explore the interplay between organisational, professional and psychological characteristics (Klopper et al. 2012).

A large skilled multidisciplinary workforce is required in ICU to meet clinical standards, organisational requirements and professional accreditation (Bennett 2009; CICM 2011). With high nurse:patient ratios, the ICU nurse workforce exemplifies the challenges encountered in providing a large staff cohort with adequate clinical support, supervision and professional development, while maintaining appropriate skill mix, in terms of clinical experience, for safe patient care balanced with equitable rostering that promotes job satisfaction and retention (Duffield et al. 2009; Robnett 2006).

Australia, like other OECD nations, is facing a nursing shortage predicted to become more acute (AIHW 2014; Duffield, Roche, et al. 2010; Stoddart 2010). Magnet hospital work environment qualities that reduce turnover and improve clinical care and safety, enhance organisational efficiency and assist cost containment (Aiken et al. 2011; Mullarkey, Duffy & Timmins 2011; Poghosyan, Aiken & Sloane 2009). The positive workplace culture created encompasses an interdependent balance of open communication and interactions, professional conduct and knowledge based best practice, supportive team dynamics and power relationships, emotionally intelligent moral paradigms and acknowledges participant expectations (Callicutt et al. 2011; Ganey 2015; Hickey et al. 2010; Middleton et al. 2008).

Conversely, dissatisfaction and worsening staff turnover have been associated with health service organisations that aim to improve productivity through reduced patient length of stay and work intensification (Aiken & Fagin 1997; Burke 2003; Gershon et al. 2004). Other factors include ineffective local leadership, disproportionate workload due to patient acuity and complexity, inflexible rostering, poor collegial interactions, staff shortages, unpredictable work flow, lack of control over practice and the perception that patient care is not coordinated, evidence based or unsafe (Groff Paris & Terhaar 2010; Li & Jones 2012; Papathanassoglou et al. 2012). Understanding these factors in relation to the hot-floor model is crucial for retaining qualified nurses (Stone et al. 2007) and improving quality of care (Chan et al. 2012; Hayes et al. 2006) for organisational sustainability.

Acute care work environments have been studied extensively (Xiao et al. 2017) but there is limited evidence pertaining to ICU with limited studies on communication, leadership, staffing models, autonomy, burnout and education programs associated with patient adverse events (Dietz et al. 2014; Mullarkey, Duffy & Timmins 2011; van Mol et al. 2015). Neonatal ICU work environments have received some attention (Garland 2010; Goldschmidt & Gordin 2006) but not adult ICUs. An appropriate dataset and selection of an appropriate survey instrument (Ulrich et al. 2014a) is required to evaluate and compare ICU nurses' work environment.

3.3.1 Literature review of nurse outcome measures

The review of clinical nurse workforce studies involved three stages (Figure 3.7). The integrative review undertaken in Stage one resulted in 26 studies being retained for full analysis involving methodological quality appraisal.

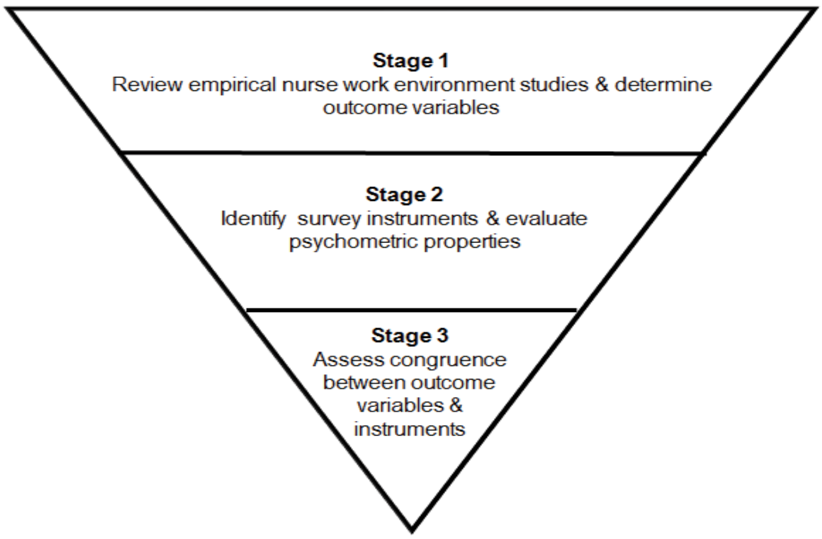


Figure 3.7 Nurse outcome and instrumentation integrative review stages

3.3.2 Quality appraisal

Evaluating the study methodology quality required the use of multiple criteria and an appropriate qualitative appraisal method. No single gold standard or guideline can be uniformly applied to all studies therefore selection of a suitable appraisal tool was required (Chan et al. 2012; Deeks et al. 2003; Whittemore & Knafl 2005).

The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement (von Elm et al. 2007) is one example that encompasses 22 criteria to assess observational cohort, case-control and cross-sectional studies. However, STROBE guides the quality of reporting on studies and is not an appropriate tool to be used solely for assessing methodological quality due to the potential for bias to be introduced in the appraisal (da Costa et al. 2012).

Alternatively, the Quality Assessment Tool for Quantitative Studies (QATQS) has been demonstrated to possess high content validity and inter-rater reliability using Cohen's Kappa (Deeks et al. 2003; Jackson & Waters 2005; Thomas et al. 2004). However, evaluation of QATQS against the Cochrane Collaboration Risk of Bias Tool found that the QATQS psychometric properties require further validation in a range of research fields to accurately interpret results when used for quality appraisal (Armijo-Olivo et al. 2012; Higgins & Green 2008).

A third option is the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, which provides recommendations on the frameworks and processes to conduct a quality appraisal during systematic reviews (Moher et al. 2009) and directly relevant for an integrative review. The Critical Review of Quantitative Research Worksheet (Miller 2006) aligned with multiple items common to STROBE, QATQS and PRISMA, and was therefore used as a basis for the quality criteria to assess the empirical nurse outcome studies reviewed. The process followed the five-stages described in Figure 3.8.

Criteria specified in the flow diagram were incorporated into a derived quality index assessment tool (see Table 3.5). Building on the criteria specified by Miller (2006) quality scores were derived based upon an evidence hierarchy proposed by Evans (2003) using a scores one, two or three for each criteria according to quality index definitions (see Table 3.6). This scoring process was first developed by Beck (1995) and later used in a review of nurse turnover costs conducted by Li et al. (2012). Methodological strengths and weaknesses were assessed generating scores that all contributed to a composite score, or index, for relative quality.

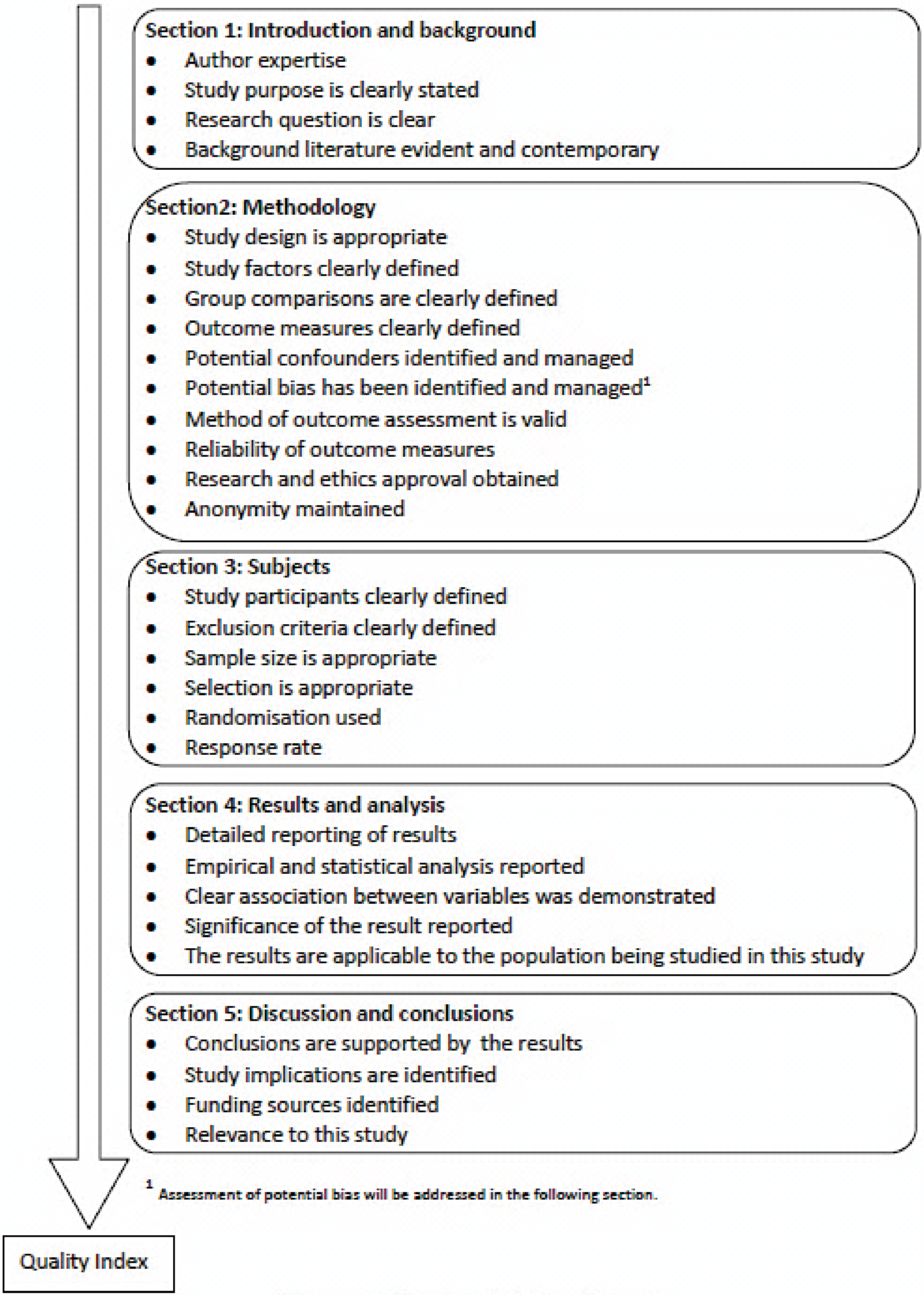


Figure 3.8 Quality appraisal flow diagram
Source: (Chan et al. 2012) pp. 4

Table 3.5 Derived quality index of nurse outcome studies

Criteria (Definitions Table 3.6)	Author expertise	Country	No. Of research sites	Purpose stated	Research question clear	Contemporay literature context	Study design	Study factors identified	Group comparisons defined	Outcomes defined	Bias risk minimised[1]	Confounding addressed	Outcome assessment instrument validated	Survey Administration	Research ethics approval	Subject anonymity	Study popn. defined	Exlcusion criteria clear	Sample selection	Sample size	Response rate	Descriptive results presented clearly	Empirical statistics include CI, SD or SE	Associations demonstrated	Significance reported	Results applicable to study population	Rlationships within results identified	Conclusions are supported by the results	Implications or Relevance stated	Limitations identified	Conflicts stated	Composite score[2] (77)	Quality Index Score %
1. Papanassoglou et al. 2012	3	1	3	2	2	2	2	2	2	2	3	2	3	1	2	2	2	1	1	3	3	2	2	2	2	2	3	2	3	2	2	66	86
2. Karanikola et al. 2012	3	1	2	2	2	2	2	2	2	2	2	2	3	1	2	2	3	2	3	3	3	2	2	2	2	2	3	2	3	2	2	68	88
3. Klopper et al. 2012	3	1	2	2	2	3	2	2	2	2	2	2	3	2	2	2	3	2	2	3	1	2	1	2	2	2	3	2	3	2	2	66	86
4. Aiken et al. 2011	3	1	3	1	1	3	2	2	2	2	2	3	3	1	2	2	3	1	3	3	2	2	1	2	2	2	3	2	3	1	2	65	84
5. Neff et al. 2011	3	1	2	2	2	3	2	2	2	2	2	3	3	1	2	2	3	1	3	3	2	2	1	1	2	3	2	2	3	1	2	65	84
6. Gasparino et al. 2011	2	1	2	2	2	2	2	2	2	2	3	3	3	2	2	2	3	3	2	3	3	2	2	2	2	3	3	2	3	1	2	70	91
7. Meeusen et al. 2011	3	1	2	2	2	2	2	2	2	2	2	3	3	1	2	2	3	1	2	3	2	1	1	2	2	3	3	2	3	1	1	63	82
8. Iliopoulou et al. 2010	2	1	2	2	2	2	2	2	2	2	2	3	3	1	2	2	3	1	1	3	3	2	2	2	2	3	3	2	3	1	2	65	85
9. Aitken et al. 2010	3	2	2	2	2	3	2	2	2	2	3	3	3	2	2	2	3	2	1	2	2	2	2	2	2	3	3	2	3	2	2	70	91
10. Purdy et al. 2010	3	1	2	2	2	2	2	2	2	2	2	2	3	1	2	2	2	1	1	3	1	2	2	2	2	2	3	2	3	2	2	62	81
11. Roche et al. 2010	2	2	2	2	2	3	1	2	2	2	2	2	3	1	2	2	2	1	1	3	3	2	2	2	2	2	3	2	3	2	3	65	84
12. Van Bogaert et al. 2010	2	1	2	2	2	2	2	2	2	2	2	3	3	1	2	2	2	1	3	3	2	2	2	2	2	3	3	2	3	1	2	65	84
13. Duffield et al. 2010	3	2	2	1	2	3	1	2	2	2	2	2	3	1	2	2	2	1	1	3	3	2	2	2	2	2	3	2	3	1	2	63	82
14. Cai et al. 2009	2	1	2	2	2	2	2	2	2	2	2	3	3	1	2	2	3	1	1	2	3	2	2	2	2	2	3	2	2	2	2	63	82
15. Cho et al. 2009	3	1	2	2	2	3	2	2	2	2	3	3	3	1	2	2	3	1	2	3	3	2	2	2	2	3	3	2	2	2	2	69	90
16. Van Bogaert et al. 2009	2	1	2	2	2	3	2	2	2	2	1	3	3	2	2	2	2	1	1	2	3	2	2	2	2	2	3	2	3	2	2	64	83
17. Aiken et al. 2008	3	1	2	2	2	3	2	2	2	2	2	3	3	2	2	2	2	1	3	3	2	2	2	2	2	3	3	2	3	2	2	69	90
18. Faulkner et al. 2008	2	1	2	2	2	3	1	2	2	2	2	3	3	2	2	2	2	1	2	3	2	2	2	2	2	3	3	2	3	2	2	66	86
19. Manojlovich et al. 2008	3	1	2	2	2	2	2	2	2	2	2	3	3	2	2	2	3	2	2	3	3	2	2	2	2	3	3	2	2	2	2	69	90
20. Middleton et al. 2008	3	2	1	2	2	2	2	1	2	2	1	2	3	1	1	2	2	1	1	1	3	2	2	2	2	3	3	2	3	2	2	**60**	**78**
21. Lai et al. 2008	3	1	1	2	2	3	2	2	2	2	2	2	1	1	2	2	3	2	1	2	3	2	2	2	2	3	2	2	2	2	2	62	81
22. Duffield et al 2007	3	2	2	2	2	3	2	2	2	2	3	3	3	1	2	2	3	2	2	3	3	2	2	2	2	3	3	2	3	2	2	**72**	**94**
23. Stordeur et al. 2007	3	1	2	2	2	2	2	2	2	2	2	3	2	1	2	2	2	1	2	3	2	2	2	2	2	2	3	2	3	2	2	64	83
24. Stone et al. 2006	2	1	2	2	2	2	2	2	2	2	2	3	3	2	2	2	3	1	3	3	2	2	2	2	2	3	3	2	3	2	2	68	88
25. Manojlovich et al. 2005	3	1	2	2	2	2	2	2	2	2	2	3	3	1	2	2	3	1	3	3	2	1	1	2	2	3	3	2	3	1	2	65	84
26. Minvielle et al. 2005	3	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	1	2	3	3	2	2	2	2	2	3	2	3	1	2	63	82
Composite score[3]>	**70**	**31**	**52**	**50**	**51**	**64**	**49**	**51**	**52**	**52**	**55**	**69**	**74**	**34**	**51**	**52**	**67**	**34**	**49**	**72**	**64**	**50**	**47**	**51**	**52**	**67**	**76**	**52**	**74**	**43**	**52**		
Potential score >	78	52	78	52	52	78	52	52	52	52	78	78	78	52	52	52	78	78	78	78	78	52	52	52	52	78	78	52	78	52	78		

1. Assessment of potential bias will be addressed in the following section. 2. Potential composite score per publication 77 points 3. Potential composite score per criteria out of 3 (78) or 2 (52) points.

Table 3.6 Derived quality index definitions

Quality Criteria	Rating Scale		
Author expertise	1. Bachelor/Masters	2. PhD	3. PhD published
Country location	1. Non-Australian	2. Australian study	3. N/A
No. of research sites	1. Single hospital/ICU	2. Multisite (national)	3. Multisite (international)
Purpose stated	1. Not clear	2. Evident	3. N/A
Research question clear	1. Not clear	2. Evident	3. N/A
Contemporay literature context	1. Inadequate and not contemporary	2. Contemporary but limited	3. Comprehensive and contemporary
Study design	1. Restrospective	2. Prospective	3. N/A
Study factors identified	1. Not clearly defined	2. Clearly defined	3. N/A
Group comparisons defined	1. Not clear	2. Yes	3. N/A
Outcomes defined	1. Not clear	2. Yes	3. N/A
Bias risk[2]	1. Present not addressed (High risk)	2. Present partally addressed (Moderate risk)	3. Present adequately addressed (Low risk)
Confounding addressed	1. Not acknowledged	2. Acknowledged but not addressed	3. Acknowledged and addressed
Outcome assessment validated	1. No validation described	2. Limited validation described	3. Published repeated validation
Survey Administration	1. Self administered	2. Facilitated	3. N/A
Research ethics approval	1. Not stated	2. Obtained	3. N/A
Subject anonymity	1. No	2. Yes	3. N/A
Study popn. defined	1. Not clear	2. Limited definition	3. Clearly defined
Exlcusion criteria clear	1. Not stated	2. Listed	3. Listed and justified
Sample selection	1. Convenience	2. Squential by protocol	3. Randomised
Sample size	1. Small < 100	2. Adequate >100	3. Large > 250
Response rate	1. < 35%	2. 35% - 70%	3. > 70%
Descriptive results presented clearly	1. No	2. Yes	3. N/A
Empirical statistics include CI, SD or SE	1. No	2. Yes	3. N/A
Associations demonstrated	1. No	2. Yes	3. N/A
Significance reported	1. No	2. Yes	3. N/A
Results applicable to study population	1. No	2. Yes with potential confounding	3. Directly applicable
Relationships within results identified	1. No	2. Yes marginal	3. Yes with complex linkages shown
Conclusions are supported by the results	1. No	2. Yes	3. N/A
Relevance stated	1. No	2. Yes marginal	3. Yes comprehensive
Funding received and source identified	1. No	2. Yes	3. N/A
Limitations identified	1. No	2. Yes	3. N/A
Conflicts stated	1. Yes – may impact but no mitigation	2. Nil declared	3. Yes – mitigation provided

The derived quality index included 31 criteria used to assess the context, methodology, subjects, results and analysis, conclusions and discussions, and relevance of the studies. The highest score attainable is 77 and is derived from the addition of the scores for each criterion to generate a composite score that was then converted to a percentage providing an indication of relative quality for each study. Across a majority of the studies there appeared to be a weakness in the assessment and mitigation of the risk of bias compounded by convenience sampling and poorly defined exclusion criteria. While potential confounding was addressed in a majority of studies through large sample sizes, stratification of staff characteristics and matching of health service size and complexity, there is a need to undertake a more formalised assessment of the risk of bias. Actual or potential bias was assessed using a risk assessment process adapted from a systematic review from the Cochrane Database of Systematic Reviews (Inglis et al. 2010), with risk of bias ranked using as a shaded 'traffic light' system to inform the assessment of risk (see Table 3.7).

Seven criteria are used relating to adequate sample size; suitable sample selection, multicentre studies; study power to detect difference; nursing staff stratification and matching; the clinical environment and demonstration of repeated published survey instrument validation to assess nurse outcomes. The level of risk is rated as high (potentially present not mitigated), moderate (potentially present partially mitigated) or low risk (potentially present but adequately mitigated) for each criteria in each study.

The analysis demonstrated a low risk of bias for 19% of studies (n = 5), moderate risk for 73% of studies (n=19) and high risk for 8% of studies (n=2). Studies ranked high risk had small convenience sample sizes, no power estimates to detect a significant association between nurse outcomes and the practice environment, and limited sites with one study using a single site (Middleton et al. 2008). Moderate risk studies did identify potential bias risks and had implemented measures to at least partially mitigate the risk of bias through for example stratifying and matching staff by qualification and experience (Aiken et al. 2011; Karanikola et al. 2012; Klopper et al. 2012). Low risk studies had no apparent major risks and where present reported this as a limitation and took comprehensive mitigation measures such as strict sample selection, calculation of the study power required and recruiting large sample sizes in multiple similar locations (Aitken et al. 2010; Gasparino, de Brito Guirardello & Aiken 2011; Papathanassoglou et al. 2012).

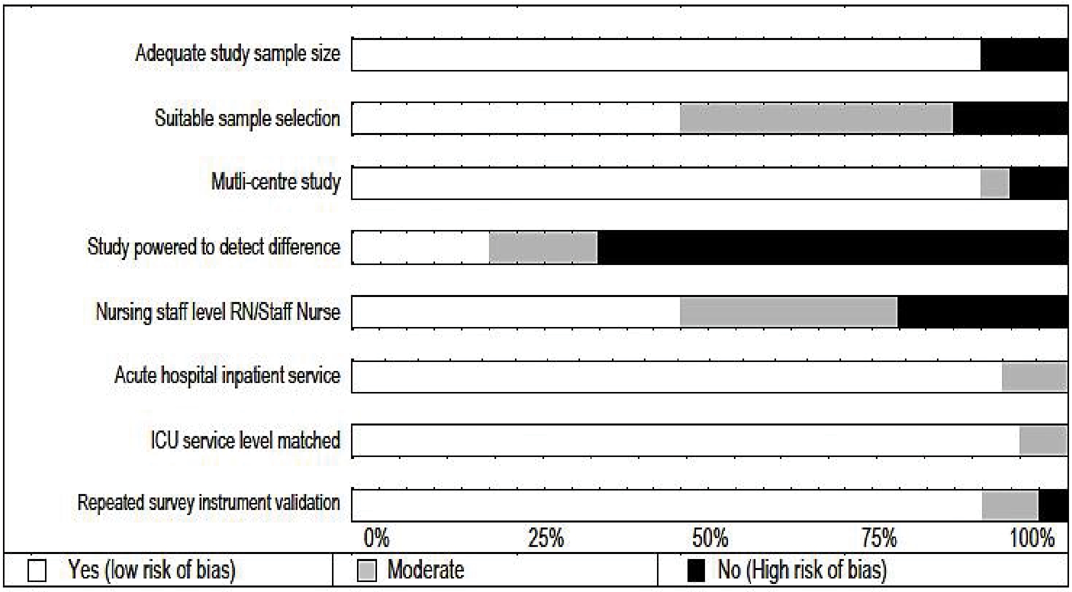
Table 3.7 Risk of bias in nurse outcome studies

	Adequate study sample size	Suitable sample selection	Multicentre study	Study powered to detect difference	Nursing staff level RN/Staff Nurse	Acute inpatient hospital service	ICU service level matched	Repeated survey instrument validation
Papanassoglou et al. 2012	◍	○	◍	◍	○	◍	◍	◍
Karanikola et al. 2012	◍	○	◍	◍	●	◍	◍	◍
Klopper et al. 2012	◍	○	◍	●	◍	◍	◍	◍
Aiken et al. 2011	◍	○	◍	○	◍	◍	◍	◍
Neff et al. 2011	◍	◍	◍	○	◍	◍	◍	◍
Gasparino et al. 2011	◍	◍	◍	◍	◍	◍	◍	◍
Meeusen et al. 2011	◍	◍	◍	○	◍	◍	◍	◍
Iliopoulou et al. 2010	◍	○	◍	○	◍	◍	◍	◍
Aitken et al. 2010	◍	◍	◍	◍	◍	◍	◍	◍
Purdy et al. 2010	◍	●	◍	●	●	◍	N/A	◍
Roche et al. 2010	◍	○	◍	●	●	◍	N/A	◍
Van Bogaert et al. 2010	◍	◍	◍	●	●	◍	◍	◍
Duffield et al. 2010	◍	○	◍	●	●	◍	N/A	◍
Cai et al. 2009	●	○	○	●	●	◍	N/A	◍
Cho et al. 2009	◍	◍	◍	●	◍	N/A	◍	◍
Van Bogaert et al. 2009	●	●	◍	●	○	◍	N/A	◍
Aiken et al. 2008	◍	◍	◍	●	○	◍	N/A	◍
Faulkner et al. 2008	◍	◍	◍	●	○	◍	N/A	◍
Manojlovich et al. 2008	◍	●	◍	●	◍	N/A	◍	◍
Middleton et al. 2008	●	●	●	●	○	◍	N/A	○
Lai et al. 2008	◍	○	●	●	◍	N/A	◍	○
Duffield et al 2007	◍	◍	◍	◍	◍	◍	N/A	◍
Stordeur et al. 2007	◍	◍	◍	●	○	◍	N/A	●
Stone et al. 2006	◍	◍	◍	●	◍	◍	◍	◍
Manojlovich et al. 2005	◍	◍	◍	●	○	◍	N/A	◍
Minvielle et al. 2005	◍	○	◍	●	○	N/A	◍	◍
□ Yes (low risk of bias)	▩ Moderate				■ No (High risk of bias)			

Source: (Inglis et al. 2010) pp.18

This information is presented in Table 3.8 as the relative bias risk for each of the bias quality criteria assessed. The score generated for risk of bias contributes to the composite quality index score.

Table 3.8 Relative risk of bias for all nurse outcome studies



Performing an estimate of the power required to detect any difference was the weakest criteria across the majority of studies with 17 (65%) not including this estimate. Failure to consider matching nurses according to role, experience and qualifications was found in six studies (23%) with poorly defined sample selection criteria in four studies (15%) and small sample size in three studies (12%) being the other areas of weakness that increased to risk bias. A majority of studies assessed and adequately addressed the risk of bias (von Elm et al. 2007).

In summary, statistical methods were well described and confounding was addressed through sample size and selection criteria along with the stratification and examination of subgroups and interactions. Missing data were managed by excluding incomplete survey responses. Prospective cohort studies addressed loss to follow up by excluding those records while maintaining and adequate sample size (Meeusen et al. 2011; Purdy et al. 2010). Twenty-two studies used a prospective cross-sectional design with convenience sampling primarily used. This potential weakness in study design was countered with large multicentre sample sizes. Sensitivity analysis would have enhanced methodological strength but this was not conducted by any of the studies assessed. Two small studies (Middleton et al. 2008; Van Bogaert et al. 2009) were weak in a number of bias and quality criteria. However, the associations found with nurse participation, perception of leadership, collegiality and nurse perception with staffing and resourcing, and the practice environment were consistent with large studies (Aitken et al. 2010; Duffield, Diers, et al. 2011; Klopper et al. 2012) providing support for inclusion.

Overall the studies had a high mean quality index score of 85%, low to moderate risk of bias and demonstrated outcome measure repeatability indicating high reliability for determining the minimum dataset. Twenty-one nurse outcomes in acute and intensive care work environment were identified. Nurse outcome measures identified from the integrative review are listed in Table 3.9.

Table 3.9 Nurse outcome measures minimum dataset

#	Nurse Outcome
1.	Autonomy
2.	Control over practice
3.	Empowerment
4.	Role conflict or ambiguity
5.	Nursing foundations
6.	Participation
7.	Leadership
8.	Collegiality (Doctor)
9.	Collegiality (Nursing)
10.	Resourcing and staffing
11.	Flexible scheduling
12.	Access to professional development
13.	Personal accomplishment
14.	Professional advancement /recognition
15.	Professional perception
16.	Satisfaction with nursing
17.	Job satisfaction
18.	Emotional exhaustion (burnout)
19.	Moral distress and anxiety
20.	Depersonalisation
21.	Intention to leave

Detailed definitions of nurse outcomes, provided in Appendix 4, inform conceptualisation their relevance to the work environment in relation organisational factors, operational processes and the psychosocial perceptions held by nurses. The most appropriate survey instrument to evaluate the work environment needs to demonstrate a high level of congruence with the identified nurse outcomes to comprehensively evaluate the work environment (AACN 2005; Hickey et al. 2010; Spence Laschinger, Almost & Tuer-Hodes 2003).

3.4 Nurse work environment survey instruments

The integrative review of nurse outcomes and the process conducted to determine appropriate survey instrumentation for this study is published in *Abbenbroek, B., Duffield, C. & Elliott, D. (2014b), 'Selection of an instrument to evaluate the organizational environment of nurses working in intensive care: an integrative review', Journal of Hospital Administration, vol. 3, no. 6, pp. 143-62* (see Appendix 5). The key steps taken are summarised below with a detailed description of selected instrumentation provided in Chapter 4 Methods section 4.6.3.

Twenty-five survey instruments (see Appendix 6) were identified in the integrative review. The Nurse Work Index-Revised (NWI-R) (Aiken & Patrician 2000), Practice Environment Scale-Nurse Work Index (PES-NWI) (Lake 2002) and Maslach's Burnout Inventory (MBI) (Maslach & Jackson 1981a) demonstrated the highest level of reproducibility, use in ICU and reliability as summarised in Table 3.10.

Table 3.10 Survey instrument reliability

Source: (Abbenbroek, Duffield & Elliott 2014b) pp. 156

Quality and validity factors	Survey Instrument		
	NWI-R	PES-NWI	MBI
Frequency	7	11	13
Testing repeated	Yes (multicenter)	Yes (multicenter)	Yes (multicenter)
Large study population (range)	155 to 2,287	67 to 98,116	55 to 98,116
Tested in nursing populations	Yes	Yes	Yes
Conducted in ICU	2/7	4/11	3/13
Organizational content validity	Yes	Yes	Yes (interpersonal)
Cronbach's alpha	α 85	α 81	α 82

The three survey instruments were tested repeatedly in multicentre studies with large nurse samples in acute care and ICU environments, though PES-NWI and MBI had been used more frequently. All instruments demonstrated an acceptable level of reliability, with mean composite Cronbach's alpha coefficients greater than 0.7. Furthermore, all three instruments had the highest level of congruence with the nurse outcomes dataset (see Table 3.11) with the NWI-R aligned with sixteen outcomes and PES-NWI with seventeen. Higher congruence with the identified nurse outcomes, demonstrated content validity, an ability to discriminate positive work environment characteristics, repeated testing and strong psychometric properties supported selection of the PES-NWI as the preferred survey instrument.

Table 3.11 Survey instrument congruence with nurse outcomes
Source: (Abbenbroek, Duffield & Elliott 2014b) pp. 156 (see Appendix 5)

Nurse Outcome	Congruence with Nurse Outcomes		
Autonomy	Yes	Yes	No
Control over practice	Yes	Yes	No
Empowerment	Yes	Yes	No
Role conflict or ambiguity	Yes	Yes	No
Nursing foundations	Yes	Yes	No
Participation	Yes	Yes	Optional questions
Leadership	Yes	Yes	No
Collegiality (Doctor)	Yes	Yes	No
Collegiality (Nursing)	Yes	Yes	No
Resourcing and staffing	Yes	Yes	No
Flexible scheduling	Yes	Yes	No
Access to professional development	Yes	Yes	No
Personal accomplishment	Yes	Yes	Yes
Professional advancement /recognition	Yes	Yes	No
Professional perception	Yes	Yes	No
Satisfaction with nursing	No	Yes	No
Job satisfaction	No	No	Yes
Emotional exhaustion (burnout)	No	No	Yes
Moral distress and anxiety	No	No	Yes
Depersonalisation	No	No	Yes
Intention to leave	Yes	Yes	Yes

The MBI encapsulated six outcome measures listed in Table 3.9 including level of participation, job satisfaction, emotional exhaustion (burnout), moral distress and anxiety, and depersonalisation. Four outcomes captured by the MBI are not captured by the NWI-R and PES-NWI providing the justification to also add the MBI to the nurse survey instrument selected. The structure and content of the selected PES-NWI and MBI survey instruments are described under instrumentation in the following chapter.

3.5 Summary

The two integrative literature reviews described in Chapter 3 resulted in the identification of patient outcomes, unit level measures of effectiveness and selection of the nurse survey instruments for this study. In Chapter 4 the proposed study design and methods employed to evaluate the hot-floor model, using the outcome dataset and selected survey instruments, are specified.

4 METHODS

4.1 Introduction

The emerging ICU hot-floor model exemplifies contemporary organisational practices for the delivery of critical care services. Chapter 2 explored this in the context of the evolution of intensive care as a clinical specialty and the drivers of change to ICU organisation and operational management. Operational processes have evolved with developments in evidence based best practice and management. The conceptual framework for this study is based on the interdependent relationships between the association of organisational factors and processes in ICU, with the outcomes for patients and nurses and unit level effectiveness, described in Chapter 3. However, the association is not well understood and therefore outcome measures, mediated by organisational factors, were identified from relevant literature to facilitate investigation of this phenomenon. This Chapter outlines the methods used to evaluate the hot-floor model compared to a traditional ICU.

The overall approach to this research is initially described before study design, setting, selection criteria and procedures, specific to the patient outcomes study and nurse outcomes study, are then explained separately. Lastly, the foundations required for robust and ethical enquiry, as they apply to both studies, are established.

4.2 Aim

The aim of this research was to determine if there were significant differences in patient and nurse outcomes between the ICU hot-floor model (ICUA) and a conventional ICU model (ICUB), and confirm if the hot-floor model achieved high organisational reliability in terms of efficiency and effectiveness.

4.3 Design

A two-method two-site study design was used with the approach taken to conduct both the patient outcome study and nurse outcome study described schematically in Figure 4.1.

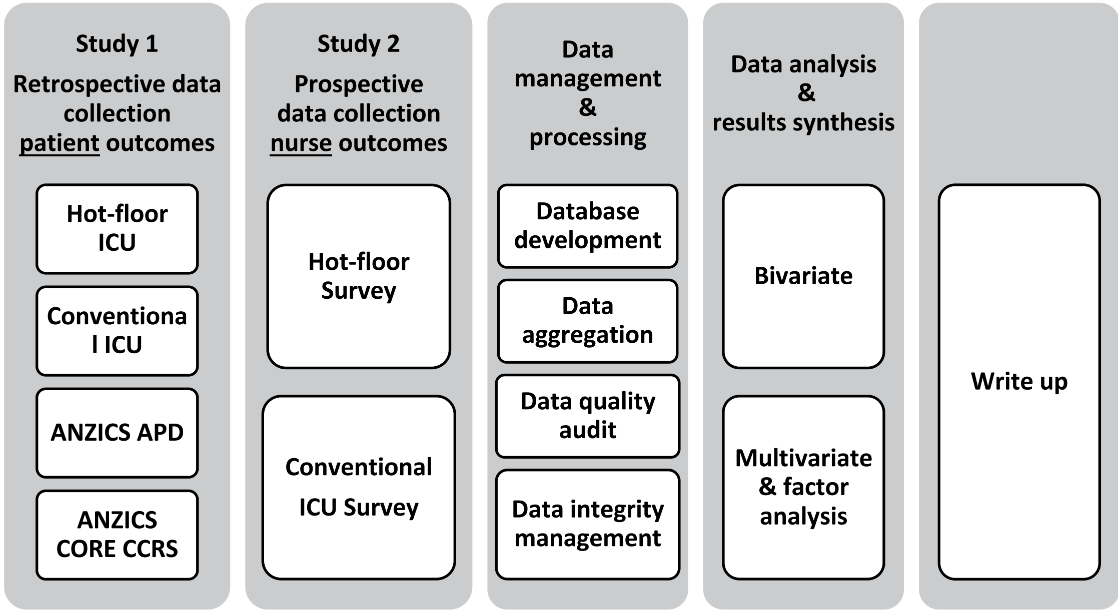


Figure 4.1 Research approach

The patient outcomes study employed a retrospective cohort design to compare two patient groups, one each from the hot-floor ICU (ICUA) and the conventional ICU (ICUB). The cohort design enabled multiple outcome variables to be examined. The nurse outcomes study used a cross-sectional survey design to determine if differences exist between nurse groups from ICUA and ICUB at a selected point in time. The non-interventional design enabled non-intrusive study of outcomes as they occur in the work environment.

This multiple-methods cross sectional study, involving both retrospective and prospective collection periods, had the potential to impede the integration of findings in regard to nurse sensitive patient outcome measures. In recognition of the need to meaningfully interpret results and collectively discuss the findings of each study, the service profile and activity at each study site were reviewed during the retrospective and prospective study periods to establish that no organisational or operational changes had occurred (see Section 5.2). Furthermore, a longitudinal view of the nurse workforce at quarterly intervals for the complete duration of the research was conducted, to ascertain if any workforce variation in terms of structure, resourcing and staffing models (see Section 5.3).

Quantitative methods were used for this research due to the 'realist' nature of the phenomenon of interest i.e. the aim was to objectively discover a potential reality existing in the ICU using methods that minimise subjectivity by the researcher. Positivism is the most extreme form of quantitative methodology relying on fixed laws of cause and effect tested through reliable measurement (Bowling 2014). However, achieving complete objectivity in this study was not feasible as no direct causation can be attributed and detached objectivity is not possible due to the study setting and context. This experimental realism led to post-positive interpretive philosophy being adopted to approximate the objective reality being studied through observation, exploration of association and probability.

Post-positivism is a pragmatic quantitative approach that supports the generalisation of findings to a population with the meaning and truth of any idea being a function of its practical outcomes (Peirce et al. 1982). Pragmatism is focused on the linking of practice and theory, and describes a process where theory is extracted from practice, and applied back to practice to form what is called intelligent practice (Decker 2012). This then builds on the body of knowledge that exists regarding the impact of organisational factors on patient and nursing staff outcomes by exploring these phenomena specifically in the ICU (Polgar & Thomas 2013).

4.4 Study settings

Selection of the hot-floor ICU (ICUA) and conventional ICU (ICUB) for this study was based on matching two sample ICUs across multiple criteria, listed in Table 4.1.

Purposive homogeneous sampling was used to ensure the tertiary adult ICU study settings had a similar service level, operational management, patient casemix, clinical processes and workforce structures. Matching ICUA, nested physically and organisationally within an ICU hot-floor service, and ICUB, a conventional standalone unit, on these characteristics enabled variation within the clinical work environments to be controlled.

4.5 Patient outcomes study procedures

The following section describes the assumptions and sample calculation estimates applied to the patient arm of this study. The steps and processes used for data collection are then summarised.

Table 4.1 Study setting selection criteria

Core ICU Characteristics		Organisational Attribute
Service delivery structural characteristics	Classification	Public Hospital
		Adult tertiary referral ICU
		General ICUA (nested within a hot-floor service)
		General ICUB (standalone conventional ICU)
		College of Intensive Care Medicine Level 3
		Training accreditation
	Capacity	General ICU bed numbers
	Clinical specialities	Hospital level & state specialist referral services
	Clinical support role	Rapid response, outreach and clinical procedures
	Activity	Admissions, patient volume, occupancy, LoS
Operational management	Patient casemix	Age, gender, diagnosis, severity of Illness, invasive ventilation and mortality (crude/SMR)
	Clinical care processes	Clinician competencies
		Prophylaxis bundles and protocols
		Pharmacist and microbiologist rounds
	Quality activities	Hospital acquired infection prevention & reporting
		Adverse event prevention, monitoring & reporting
		Mortality and morbidity reviews
Workforce	Organisation	Nursing, medical, allied and ancillary staff
	Resourcing	Staffing establishment for nursing, medical, allied and ancillary staff
		Nurse vacancies
		Levels of clinical experience
		Proportion of intensive care qualified staff
	Shift staffing model	Staff resources in business and after-hours
	Stability	Staffing for the duration of the study (Jan 2013 – June 2014)

4.5.1 Sampling

The population of interest was adult patients with critical illness or injuries admitted to a general ICU in a public hospital in Australia. Inclusion criteria for participants were all adult ICU (> 16 years) inpatients that had a completed episode of care between 1 January and 31 December 2013 in the two study sites, from both planned and unplanned admission sources. Patient casemix was controlled through multiple factors including severity of illness and the service level of ICUA and ICUB. An appropriate sample size was calculated through power analysis to ensure stability of the parameters generated in the results (Ferketich & Verran 1990). Power was set at 0.80 (Cohen 2013).

Effect size estimation was based on the standard deviation of the primary outcome of crude mortality ($\sigma = 0.0243$), a gold standard patient outcome measure routinely reported for all Australian tertiary level ICUs (n=31) to the ANZICS APD in 2013. This variation reflected a small effect size (range 0.02-0.15). A calculation was performed using G-power (http://www.gpower.hhu.de/en.html) for one and two-tailed tests with a small effect size of 0.1, alpha set at 0.05, and a power of 0.8 for two groups, to determine the appropriate sample size of 500 patients from each site, resulting in a total of 1000 patients (Cohen 2013; Kang 2015).

Moderate precision ($\alpha = 0.05$) was considered appropriate given the health services research nature of the study, as opposed to a clinical intervention study such as a drug trial (Bowling 2014). The sample size aimed to provide adequate power to reduce the probability of a type I error or a type II error during statistical analysis (Pereira & Leslie 2009).

A comparable range of sample sizes, from approx. 200 to 2000 patients, was used in similar studies of organisational factors in ICU including Intensivist cover, continuity of care, practice standardisation and organizational factors impacting on high risk ICU patients (Ali et al. 2011; Garland, Roberts & Graff 2012; Jarachovic et al. 2011; van der Sluis et al. 2011).

4.5.2 Data Collection

Patient clinical and demographic data were collected for the 2013 calendar year enabling seasonal fluctuations and corresponding operational changes to be captured (Green 2005; Hultman et al. 2012). Patient outcome measures collected are listed in Table 4.2.

Table 4.2 Patient and unit level variables

#	Outcome Measure
1	Unplanned Extubation (UE)
2	Central Line Associated Blood Stream Infection (CLABSI)
3	Pressure Ulceration (PU)
4	Venous Thrombosis Embolism Prophylaxis (VTEP) compliance
5	Length of Stay (LoS)
6	Crude Mortality (Mortality) [1]
7	After-hours Discharge (AHD)
8	Delayed Discharge (DD)
9	Unplanned Readmission to ICU (<72hours) (UR)

1. Primary outcome measure used for sample size calculations

With permission, de-identified data were accessed from each local ICU Clinical Information System (ICU-CIS) and clinical registry routinely used for patient management, data collection, monitoring and reporting, with no direct patient interaction. Data collection was facilitated through a series of meetings with each Clinical Information System Manager from ICUA and ICUB. In addition, the ANZICS APD provided data on the national tertiary adult ICU population using Excel software 15.0 (Microsoft Corporation, Redmond, Washington, USA). The data collection process is summarised in Figure 4.2.

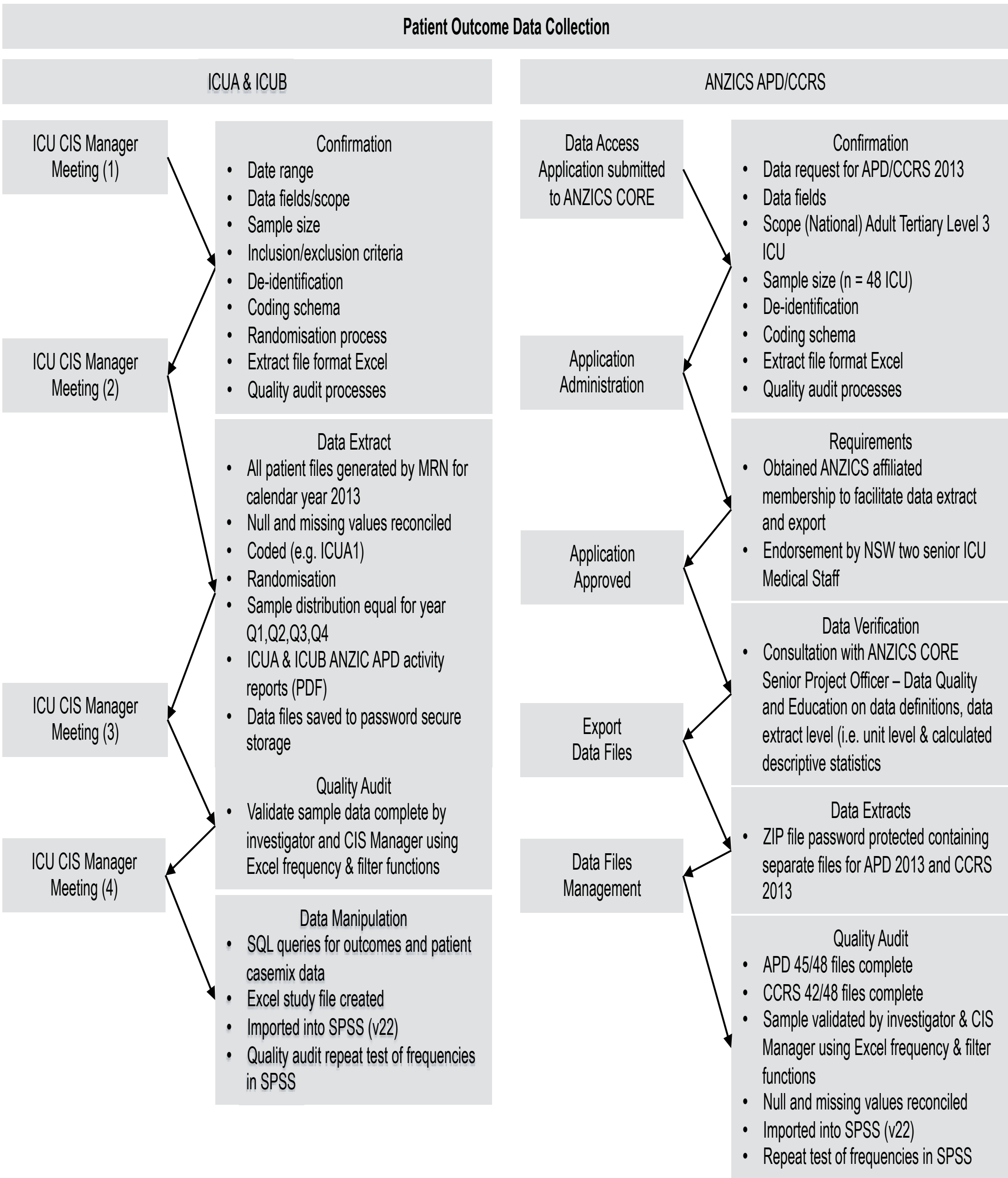


Figure 4.2 Patient data collection process

In addition to nine patient outcome measures, found to have an association with organisational factors in Chapter 3, three additional outcome measures, routinely reported as indicators of ICU quality management, were also measured: access to an ICU bed, annual volume of patients per bed, and average ICU occupancy. These are summary measures aggregated at the unit level for the full calendar year for each ICU and included to compare activity between the two study sites.

The IntelliSpace Critical Care and Anaesthesia (Philips Healthcare, Amsterdam) ICU-CIS was used in ICUA and Centricity (General Electric Healthcare, Chicago) ICU-CIS in ICUB. Data were collected according to a dictionary of terms and parameters specified by the national ANZICS APD to ensure consistency (ANZICS CORE 2013a). Data validation in the ICU-CIS is a routine practice for clinicians at the point of care with quarterly data quality checks performed by the ICU-CIS Manager prior to files being exported to the national ANZICS APD database (ANZICS CORE 2014b). Each ICU-CIS ACCESS Database 15.0 (Microsoft Corporation, Redmond, Washington, USA) was interrogated with Structured Query Language queries based on the sample inclusion criteria and specific outcomes of interest for data acquisition. Data files were then exported to Excel for the first stage of quality review and randomised sample selection.

Data files contained 1417 patient records for ICUA and 937 for ICUB. Randomisation was performed using the Excel randomisation function. The process involved manipulating each data file to create a temporary column ‘B’ next to column ‘A’ which contained the coded records (Hot-floor Nos. 1-1417: Conventional ICU Nos. 1-937). The randomisation command ‘fx =rand ()’ was copied to all rows of data. Both column ‘A’ and ‘B’ were highlighted, then the data and sort by column ‘B’ functions were used to randomise the data following which the temporary column ‘B’ was deleted. The sample size (n=500) was divided into the full year study population for each ICU to obtain the sampling fraction or interval. The sampling fraction was then used as the constant difference between subjects to ensure the selection of patients was distributed evenly across the entire 12-month study period.

4.6 Nurse outcomes study procedures

4.6.1 Sampling

The available clinical bedside nursing population during the study period from April to June 2014 (inclusive) was 112 nurses (102 FTE) in ICUA, and 84 nurses (71.5 FTE) in for ICUB. An estimated sample of 130 ICU nurses; 65 from each of the study sites was proposed, based on a previous Australian study assessing the impact of an ICU nursing practice intervention on perceptions of the practice environment, assuming a small effect, with calculated sample size of 63 participants each in two study groups (Aitken et al. 2010). As a result, that study had 80% power and detected a statistically significant difference at a significance level of 0.05 (2-tailed) in means of 0.4 with a standard error of 0.8. A comparable range of sample sizes were also used in similar studies of nursing outcomes associated with work environment factors mediated by organisational factors (Gikopoulou et al. 2014; Moneke & Umeh 2013). Moderate precision ($\alpha = 0.05$) was appropriate for the health management nature of the research, as noted earlier (Bowling 2014).

This sample size was postulated to provide adequate power, reducing the probability of type I and II errors (Pereira & Leslie 2009). To achieve the required estimated sample size, all clinical nurses working in the study sites were invited to participate with Nurse Managers (NMs) and Clinical Nurse Educators (CNEs) promoting recruitment in their respective ICUs. Inclusion criteria were Registered Nurses rostered permanently to the ICU; allocated to provide direct patient care; full time or part time employment; all levels of clinical experience; and both ICU qualified and non-ICU qualified. Recruitment occurred over a three-month period. The sample size was also considered feasible within the context of this doctoral study and the data collection period.

4.6.2 Data collection

Information sessions and presentations were conducted for clinical staff during in-service education periods, weekends and night duty at each site to explain the study purpose and review the structure and instructions for completing the nurse survey. Fourteen information sessions were conducted with 155 nurses in total attending. A ten-minute presentation on the impetus, structure and objective of the study was provided and the questionnaire reviewed to ensure instructions were clear. A Participant Information Sheet (PIS) (see Appendix 7) was provided and reviewed to offer an opportunity for questions and clarify any concerns.

In total 155 hard copy questionnaires were distributed at the information sessions (81 in ICUA and 74 in ICUB). Each survey was returned in a coded sealed envelope either at the end of the information session, or if completed later, to the Nurse Manager (NM) or Clinical Nurse Educator (CNE) Training regarding survey completion was provided to NMs and CNEs should questions arise. The NM also distributed the PIS and link to the electronic version, using Survey Monkey software (Survey Monkey Inc., Palo Alto, California, USA, www.surveymonkey.com), via email (see Appendix 8). The Survey Monkey link remained active for the three-month collection period and was configured to require all fields to be completed before progressing onto the next section or exiting the survey.

The potential impact of different survey modalities on response rates and results due to factors including survey length, format and duration, computer literacy and access to terminals is acknowledged. In a review of the adequacy of response rates to online and paper surveys by Nulty (2008), the impact of hard copy versus electronic surveys was not constant and largely dependent upon characteristics of the sample population and survey design. In this study hard copy and electronic survey methods were employed to suit the work environment and participants. Hard copies provided the opportunity for immediate completion following the face-to-face information sessions so as to capitalise on nurses being released from the bedside and the motivation generated through the session.

The electronic format was also considered suitable given the highly technical environment of the ICU and high levels of computer literacy particularly in the study units that routinely use an ICU-CIS. A review of sampling and data collection procedures in nursing research undertaken by Suhonen et al. (2015) identified that a variety of data collection procedures is associated with a large amount of missing data and may be detrimental to response rates. With this in mind a number of steps were taken to minimise variation due to survey completion effects. The hard copy survey was piloted (see Section 4.6.3), data management involved a comprehensive data quality audit and a strategy established to appropriately manage responses with missing data (see Section 4.7).

Response rates were proactively driven by a weekly email sent by the nurse manager to nursing staff as a reminder about the study and to follow up on the return of competed hard copies, which also included the link to Survey Monkey. Each survey response was registered against a confidential list, not available to the investigator, which was held by the NM to mitigate the risk of the survey being completed more than once by respondents. To complete data acquisition hard copy survey responses were transcribed into an Excel data file and combined with electronic responses. This facilitated data quality and integrity review process and preparation for analysis.

4.6.3 Instrumentation

As described in Chapter 3 the PES-NWI (Lake 2002, 2007) and MBI (Maslach & Jackson 1981a) demonstrated the highest congruence with the nurse outcome dataset and strong psychometric properties (Abbenbroek, Duffield & Elliott 2014b). The PES-NWI consists of five subscales that measure nurse participation in hospital affairs; nursing foundations for quality of care; nurse manager ability, leadership, and support of nurses; staffing and resource adequacy; and collegial nurse-physician relationships (Lake 2002). The practice environment is shaped by these organisational characteristics that either facilitate or constrain professional nursing practice (Lake 2002; Liou & Cheng 2009). A four-point scale (strongly disagree, disagree, agree and strongly agree) is used to rate the extent to which the items are present in the participant's workplace. Mean scores above 2.5 indicate agreement that the item is present in the workplace while scores below 2.5 indicate disagreement (Lake 2002). Internal consistency and reliability of subscales has been psychometrically validated based on Cronbach's alpha coefficients, used for questionnaires containing the Likert scale.

In the original development process, coefficients for each of the subscales were reported as Nurse Participation in Hospital Affairs (α=0.83); Nursing Foundations for Quality of Care (α=0.80); Nurse Manager Ability, Leadership, and Support of Nurses (α=0.84); Staffing and Resource Adequacy (α=0.80); and Collegial Nurse-Physician Relations (α=0.71), with an overall alpha of 0.82 (Lake 2002). Detailed factor analysis and psychometric validation globally (Klopper, Aiken & Coetzee 2012; Warshawsky & Havens 2011) has repeatedly scored Cronbach's α above 0.70 (Aiken, Sermeus, et al. 2012; Bonneterre et al. 2008; Gikopoulou et al. 2014).

The PES-NWI typically consists of 31 questions, but one question relating to the 'Use of Nursing Diagnoses' was omitted as it is not used in the Australian practice setting (Parker et al. 2010). The version of the PES-NWI used in this study therefore contained 30 questions (see Table 4.3).

Table 4.3 ICU Nurse Survey Section C PES-NWI

Subscale	Indicator Description	Item #
Nurse Participation in Hospital Affairs	• Career development/clinical ladder opportunity	5
	• Opportunity for nurses to participate in policy decisions	6
	• A senior nursing administrator who is highly visible and accessible to staff	11
	• A senior nursing administrator equal in power and authority to other top level hospital executives	15
	• Opportunities for advancement	17
	• Administration that listens and responds to employee concerns	21
	• Nurses are involved in the internal governance of the hospital (e.g. practice and policy committees)	23
	• Nurses have the opportunity to serve on hospital and nursing committees	27
	• Nurse managers consult with staff on daily problems and procedures	28
Nursing Foundations for Quality Care	• Active staff development or continuing education programs for nurses	4
	• High standards of nursing care are expected by the administration	14
	• A clear philosophy of nursing that pervades the patient care environment	18
	• Working with nurses who are clinically competent	19
	• An active quality assurance program	22
	• A preceptor program for newly hired nurses	25
	• Nursing care is based on a nursing rather than a medical model	26
	• Written up-to-date nursing care plans for all patients	29
	• Patient care assignments that foster continuity of care (i.e., the same nurse cares for the patient from one day to the next)	30
Nurse Manager Ability, Leadership and Support of Nurses	• A supervisory staff that is supportive of the nurses	3
	• Supervisors use mistakes as learning opportunities, not criticism	7
	• A nurse manager or immediate supervisor who is a good manager and leader	10
	• Praise and recognition for a job well done	13
	• A nurse manager or supervisor who backs up the nursing staff in decision making, even if the conflict is with a doctor	20
Staffing and Resource Adequacy	• Adequate support services allow me to spend time with my patients	1
	• Enough time and opportunity to discuss patient care problems with other nurses	8
	• Enough registered nurses on staff to provide quality patient care	9
	• Enough staff to get the work done	12
Collegial Nurse-Doctor relations	• Doctors and nurses have a good working relationship	2
	• A lot of team work between nurses and doctors	16
	• Collaboration between nurses and doctors	24

Complementing the focus on organisational factors by the PES-NWI, the MBI assesses interpersonal and psychosocial aspects of the work environment but with greater emphasis on individual perceptions and emotions implicated in burnout (Maslach & Jackson 1981a). While alternative measures of burnout have been developed, such as the Copenhagen Burnout

Inventory, the MBI remains the most widely used instrument (Kristensen et al. 2005; Neamatollahi & Jalali 2015; Poghosyan, Aiken & Sloane 2009).

Three versions of the MBI are in use; two versions were developed specifically to capture burnout in professions with challenging interpersonal interactions in human services and education, namely the MBI Health Services Survey (MBI-HSS) and MBI Educational Survey (MBI-ES) respectively (Bria et al. 2014). The MBI General Survey (MBI-GS) was developed to research professions outside human services (Bria et al. 2014). However, the MBI-HSS factor structure has been validated on samples of healthcare professionals, with the three dimensions tested found to be moderately correlated (Hallberg & Sverke 2004; Worley et al. 2008). A large international study involving eight countries in a sample of 54,738 acute care nurses confirmed that the MBI-HSS is a valid instrument to study correlates of nurse burnout globally (Poghosyan, Aiken & Sloane 2009). Furthermore, acceptable psychometric properties were confirmed with all three subscales demonstrating Cronbach's alpha above 0.7 (Poghosyan, Aiken & Sloane 2009). The MBI-HSS was therefore considered suitable for use in this study with ICU nurses.

The three subscales of the MBI-HSS measure depersonalisation, emotional exhaustion and sense of personal accomplishment (see Table 4.4). All contribute to burnout and were found to be strong predictors of a healthy work environment in Chapter 3.

Burnout has been defined as a psychological syndrome involving emotional exhaustion, depersonalisation and a diminished sense of personal accomplishment that occurs among human services professionals, such as nurses, working in challenging situations (Maslach 1982; Poghosyan, Aiken & Sloane 2009). Depersonalisation (five items) assesses the degree of detachment and impersonal care of patients; emotional exhaustion (nine items) describes feelings of being emotionally exhausted because of the work performed; and personal accomplishment (eight items) describes beliefs of competence and achievement at work.

Each item within the subscales is rated using a seven-point scale, ranging from low ("never having those feelings") to high ("having those feelings every day"). Scoring and interpretation of results is based on comparing aggregated sample means and standard deviations for each subscale with normative sample data, and in accordance with Maslach's Burnout Inventory Manual (Maslach, Jackson & Leiter 1996a).

Table 4.4 ICU Nurse Survey Section D MBI-HSS

Subscale	Indicator Description	Item #
Depersonalisation	I feel I treat some recipients as if they were impersonal objects.	5
	I've become more callous toward people since I took this job	10
	I worry that this job is hardening me emotionally	11
	I don't really care what happens to some recipients	15
	I feel recipients blame me for some of their problems	22
Emotional Exhaustion	I feel emotionally drained from my work	1
	I feel used up at the end of the workday	2
	I feel fatigued when I get up in the morning and have to face another day on the job	3
	Working with people all day is really a strain for me	6
	I feel burned out from my work	8
	I feel frustrated by my job	13
	I feel I'm working too hard on my job	14
	Working with people directly puts too much stress on me	16
	I feel like I'm at the end of my rope	20
Personal Accomplishment	I can easily understand how my recipients feel about things	4
	I deal very effectively with the problems of my recipients	7
	I feel I'm positively influencing other people's lives through my work	9
	I feel very energetic	12
	I can easily create a relaxed atmosphere with my recipients	17
	I feel exhilarated after working closely with my recipients	18
	I have accomplished many worthwhile things in this job	19
	In my work, I deal with emotional problems very calmly	21

Each score can be coded as low, average or high by using the numerical cut off points for each subscale (Maslach, Jackson & Leiter 1996a). Categorisation of the levels of depersonalisation, emotional exhaustion and personal accomplishment (see Table 4.5) according to the normative data from a sample gathered on 1,104 nurses and medical staff (Maslach, Jackson & Leiter 1996a). A high degree of burnout is reflected in high scores on the Depersonalisation and Emotional Exhaustion subscales and low scores on the Personal Accomplishment subscale. An average degree of burnout is reflected in average scores on the three subscales. A low degree of burnout is reflected in low scores on Depersonalisation and Emotional Exhaustion subscales and in high scores on the Personal Accomplishment subscale.

Table 4.5 MBI subscale categorisation per normative sample scores

	Frequency		
	DP	EE	PA
High	≥ 10	≥ 27	≤ 33
Moderate	6 – 9	19 – 26	34 – 39
Low	≤ 5	≤ 18	≥ 40

Despite this stratification being developed by the original authors of the MBI, they recommend performing statistical analysis on the original numerical scores, rather than categories. The method uses normative population means (see Table 4.6) to enhance the power of the analysis (Maslach, Jackson & Leiter 1996a).

Table 4.6 MBI normative mean subscale scores

	DP	EE	PA
Mean (n = 1,104)	7.12	22.19	36.53
SD	5.22	9.53	7.34

Based on the selected PES-NWI and MBI-HSS instruments and the remaining nurse outcomes identified in the literature review, the ICU Nurse Survey tool (see Appendix 9) used in this study consisted of four sections containing a total of 80 questions with tick-box answers. Two sections sought information on work factors and demographic characteristics, the third contained the PES-NWI and the forth the MBI-HSS. A separate section for free text comments was provided for any additional views to enrich the understanding of participants' perceptions about their work environment. Survey completion was deemed consent to participate. Survey structure, design and formatting was based on the instrument used in a previous Australian nurse outcome study (Duffield, Roche, et al. 2007).

Prior to survey administration a pilot study was conducted to ensure instructions for completion were clear, to validate the wording of questions to avoid ambiguity, determine the time taken and feasibility of completion by participants and administrative logistic issues. Using purposive sampling, the preliminary survey was tested on 14 clinical Registered Nurses from a range of tertiary level ICUs representing the study population but external to the study sample. The pilot sample size was approximately 10% of the estimated sample size for the main study and therefore considered an adequate representation (Simon & Goes 2011). Respondents were initially contacted via email to seek consent to participate in the pilot study, then provided with the PIS and a coded hard copy of the questionnaire to maintain confidentiality. The pilot group were asked to monitor the time taken for completion and to provide feedback. A return stamped self-addressed envelope was also provided. Thirteen pilot surveys were returned, a response rate of 93%, still representing approximately 10% of the main study sample size. Years of ICU experience ranged from one to 21 years providing a broad perspective of ICU experience within the pilot participants. Time taken to complete the survey was considered appropriate with a mean of 11 minutes (range 7 – 15 minutes).

Following pilot testing, minor modifications to the instrument were made. Some terms - 'care recipient', 'patient care assignment', 'nursing models' and 'Physician' were considered unclear by respondents but were fundamental to the content of the PES-NWI and MBI-HSS instruments and therefore not modified. An explanation for these terms was therefore included in the survey instrument and included in staff briefing sessions. Grammatical errors were corrected and font size maximised. Interrater reliability across respondents was high with overall agreement on the appropriateness of the structure, content, ease of completion and time taken.

4.7 Data Management

Data management for both studies was undertaken in accordance with a checklist (see Appendix 10) to ensure requirements were addressed and to review the quality of the processes implemented. Patient sample data were extracted electronically and did not require manual transcription. Nurse sample data required hard copy and electronic Survey Monkey responses to be transcribed into a single data file using Excel. Transcription of data may lead to omissions and coding errors therefore data quality and integrity was validated in multiple steps, listed in Table 4.7 (Tabachnick & Fidell 2001).

Quality and integrity of the patient sample data was high with no missing data or aberrant variables being attributable to the use of an ICU-CIS in both ICUs for clinical management and documentation. Nurse sample data were missing PES-NWI and MBI-HSS sections in five hard copy survey responses. PES-NWI accounted for approximately 37.5% of the data collected in each survey with MBI-HSS approximately 27.5% of data therefore surveys missing these sections were excluded from further analysis. A further five hard copy responses were missing an individual data variable.

Table 4.7 Patient and nurse sample data audit steps

Study 1: Patient outcomes	Study 2: Nurse outcomes
1. Data preparation working action logs created 2. Colour coding of rows and columns to differentiate to assist visual inspection 3. Run counts on variables in Excel data files for missing data in each dataset 4. Cross check patient sample data for equal distribution over the 12 month study period 5. Units of measure compliance with standardised data dictionary 6. Age, admission date and LoS per extracted file to verify record ID and no duplicated records 7. Second independent reviewer validated the data integrity prior to exporting to SPSS 8. Variable frequency counts run on the data imported in SPSS 9. Normality assumptions and outliers assessed	1. Data preparation working action logs created 2. Cross check nurse survey responses: 3. Against the coded response register for duplications 4. Hard copy survey responses transcribed verbatim to Excel file 5. Hard copy survey responses screened during transcription for missing data 6. Missing data checked with frequency counts in Excel. Missing individual variables managed by mean imputation. 7. Electronic survey mandatory response requirement configured 8. Electronic survey responses exported from 'Survey Monkey' to Excel file and screened visually and by cell frequencies for completeness 9. Excel data file from hard copy and electronic copies merged with ICUA responses in group 1 and ICUB responses in group 2 (excluding five hard copy surveys with incomplete sections item 2. 10. Colour coding of questionnaire sections, rows and columns to group sections and differentiate on visual inspection 11. Negatively worded questions reversed 12. Second independent file review 13. Exported to SPSS, file structure validated (ICUA = 1, ICUB = 2) and frequencies re-checked 14. Normality assumption and outliers assessed

No item was missing on more than one survey and no pattern was discernible in missed responses suggesting that these missing data were random rather than systematic (Grove & Burns 2005). Mean imputation was used to replace the missing observation (Coetzee et al. 2013). The potential reduction in variance and impact on data relationships due to mean imputation is acknowledged but the risk was minimal due to the small number of missing variables occurring singularly in 145 separate responses.

This completion rate compared favourably to other studies of similar nurse populations internationally (Myhren, Ekeberg & Stokland 2013; Papathanassoglou et al. 2012). Additionally, visual inspections along with data frequency and range checks were repeated to validate data integrity and ensure no transcription errors. A second independent reviewer was not involved in the study nor had any link with nursing or healthcare services. These steps combined with those previously described provided confidence regarding data integrity and suitability for aggregation and analysis. Formatting and coding of patient and nurse sample data were logged in an SPSS codebook (see Appendix 11) created to record definitions, labels and the number assigned to each response captured.

4.8 Data analysis

Data preparation, preliminary analysis, psychometric validation and the steps to be taken to determine the most appropriate statistical analysis are summarised in the data analysis plan summarised in Figure 4.3.

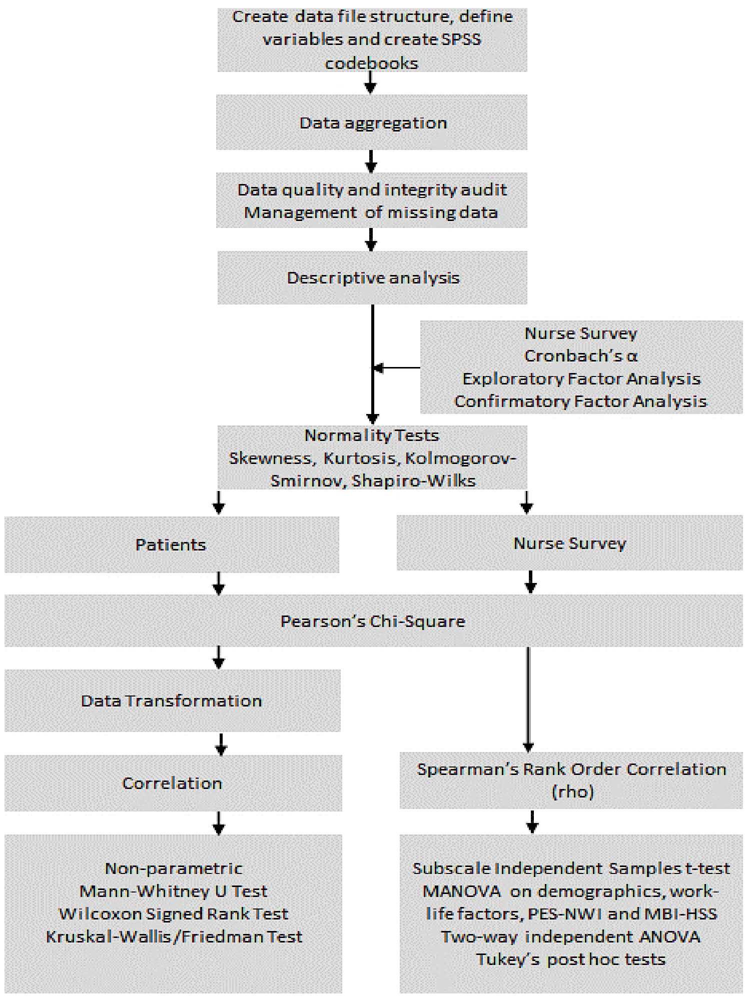


Figure 4.3 Flow diagram summarising steps taken for data preparation and analysis

Patient sample datasets consisted of continuous and categorical variables reflecting individual outcomes and unit-level operational summary measures. Patient demographics, case-mix variables and outcomes collected at the individual level were aggregated to a group-level construct for ICUA and ICUB to perform data analysis. Nurse sample datasets consisted of categorical data for nurse work and demographic variables, and ordinal data for the PES-NWI and MBI-HSS variables. Nurse work and demographic variables collected on individuals were also aggregated at unit level (see Appendix 12). The goal of this strategy was to capture organisational contextual influences on the patient care nurse work environment and identify any association with patient and/or nurse outcomes. Analysis was then undertaken to determine what proportion of the outcome could be attributed to or predicted by work environment or operational factors within the two different ICU organisational models.

Patient case-mix categories for smoking status were collapsed from five to two categories, 'smoked vs. never smoked', due to patient similarities in each ICU patient group. Admission source was also collapsed from six to four categories, 'OT, ED, Int. Transfer and Ext. Transfer', due to small numbers in two groups.

Several nurse variables within the work and demographic sections were stratified into multiple categories resulting in small counts and a number of answer options in work questions one and five were redundant as this survey was only administered to permanently rostered clinical bedside nurses. While the initial stratification provides a detailed level of granularity on these factors, the small numbers in each and nil selection of other choices resulted in small numbers that could not be meaningfully tested. Aggregation aimed to optimise the identification of any statistical difference existing and between patient groups on these variables. This is particularly relevant in categorical data analysis as there is a minimum count required in each cell to enable cross tabulation and statistical analysis (Pallant 2013).

Patient and nurse sample datasets were analysed using SPSS IBM Statistics 22 software program (SPPS IBM, New York, USA). In preparation for importing into SPSS negatively worded nurse survey response scales were reverse coded where required. This ensured all higher scores indicated the most positive responses, greatest agreement and highest frequencies on work factors, work environment characteristics and personal feelings.

Continuous and dichotomous formats enabled inferential statistical analysis techniques to be applied including tests of proportions and tests of association between the dependent (outcome) variable and independent (organisational factor) variables in each ICU. Patient sample data from both units appeared normally distributed for age and positively skewed for severity of illness and LoS (see Appendix 13). Outliers were similar in number and spread with negligible influence on sample means and were therefore retained in the analysis. However, distribution tests of variables did not support the assumption of normality (see Appendix 14), even with data transformation (see Appendix 15), non-parametric analyses were conducted. The significance level was set at .05 for all tests.

The two study sites were compared on physical structures and operational processes directly, and against the national tertiary adult ICU population. Patient throughput and activity were compared using one-sample t-tests, with admission profiles compared through non-parametric one sample binomial test of proportions. Comparison of patient casemix was performed using one sample Wilcoxon Signed Rank Tests. Non-parametric tests were applied due to the known heterogeneity within the adult ICU patient population reflected in national reporting (ANZICS CORE 2014b). Workforce structures were also compared on descriptive characteristics between study settings and where available against reported national characteristics using Chi-square analysis.

Descriptive analysis of patient and nurse samples was undertaken with Pearson Chi-square analysis. Mean scores were calculated for the PES-NWI and MBI-HSS subscales to avoid differentially weighting subscales with more items (Parker et al. 2010). This also allowed for subscale comparison using 30 of the 31 items in the original PES-NWI. Cronbach's alpha scores for subscales were calculated to assess internal consistency and reliability of the survey instruments. Ordinal survey data enabled factor analysis for the PES-NWI and MBI-HSS instruments. Initially exploratory principal component analysis was undertaken and followed by a confirmatory factor analysis to establish construct validity of the PES-NWI and MBI-HSS in the current sample.

Non-parametric statistical analysis is typical of health outcome studies due to the heterogeneity of study populations (Sakr et al. 2015). Normality assumptions for the data were initially assessed through visual inspection of data distribution in histograms. Analysis of skewness and kurtosis was then performed along Kolmogorov-Smirnov and Shapiro-Wilks statistical tests.

Spearman's Rank Order Correlation (rho) was performed on continuous variables for Age, APACHE III-J, SAPS II and LoS. Continuous measurement, related pairs of scores from the same subject and independence of observations supported use of correlations. Linearity and homoscedasticity were assessed to determine variability in scores for variables X and Y by generation of a scatterplot matrix. Data transformation was undertaken to determine if distribution improved, with results confirming that non-parametric statistical tests were most appropriate for analysis.

4.9 Ethical considerations

Privacy and confidentiality for patients, staff and the organisation was paramount. De-identified coded data and an observational study design meant no alterations to standard practice or interventions were envisaged, thereby minimising the risk of ethical issues arising. Use of an observational design was appropriate as controlling access of critically ill patients to a type of ICU or random allocation of nurses to either unit for research purposes would be unethical (Mann 2003).

Research ethics approvals were obtained from the Local Health District (LHD) lead Human Research Ethics Committee (AU/1/C741117) followed by hospital site-specific approvals (SSA/13/RPAH/165 and 13/G/224). The University Human Research Ethics Committee ratified LHD and site specific approvals (2013000014). Executive approvals were also required at both study sites. Approval was gained to use population-level data from the Australian and New Zealand Intensive Care Society (ANZICS) Australian Patient Database (APD) and Centre for Outcomes Research Evaluation (CORE). Permissions were obtained for use of the PES-NWI survey and the MBI-HSS instruments. Lastly, data were collected and stored in compliance with definitions contained in the National Statement on Ethical Conduct in Human Research (NHMRC 2007).

5 RESULTS

5.1 Introduction

Findings in regard to the study settings, patient outcomes and nurse outcomes are presented in this Chapter. Study settings are compared on physical structures, clinical and operational processes, and patient casemix attributes. Patient clinical and demographic characteristics are then compared, followed by testing for data assumptions and correlation analysis before comparing measured outcomes. Nurse sample results for professional, work and demographic characteristics are then presented, followed by results for factor analysis and analysis of variance of outcomes, as measured by PES-NWI and MBI-HSS instruments.

5.2 ICU hot-floor and conventional ICU settings

The two tertiary adult ICUs, ICUA and ICUB, selected to represent an ICU hot-floor and a conventional ICU respectively, were compared on service level features, processes, casemix and workforce characteristics as defined in Chapter 4 (see Table 4.1). Where data were available, the sample units were compared to tertiary adult ICUs nationally.

5.2.1 Structure, Process and Casemix

Multiple service level characteristics were matched in both units (see Appendix 16). Nationally in 2014, 8.0% of 31 tertiary adult ICUs were organised as a hot-floor structure. Clinical specialties were similar although the ICU hot-floor provided a liver transplant service. While liver transplants require complex surgery and recovery of systemic organ failure during the post-operative period, this service was not considered a potential confounder as increasingly patients undergoing complex surgery have multiple comorbidities requiring equivalent levels of postoperative clinical management typical of tertiary level ICUs. Similar hospital wide clinical support services were provided by both study ICUs.

Overall, the bed capacity for both units (General ICU only) was similar although bed capacity in the conventional ICU was statistically lower than the mean bed capacity in GICUs nationally by 2.13 beds ($t_{(30)}$ = - 3.27, p = 0.03; 95% CI – 3.50 to – 0.80) (see Table 5.1).

Table 5.1 Unit capacities, activity and mortality

Attribute	Source			Statistics				
	Unit n ($\bar{x}$)		National[1,2] μ	t (df,30)	SD	p [3]	95% CI	
							Lower	Upper
GICU Beds	ICUA	17	17	.198	3.63	.884	-1.20	1.50
	ICUB	15	(12 -26)	-3.27		.03	-3.50	-0.80
Total Beds	ICUA	48	23	17.19	8.25	0.00	22.40	28.40
	ICUB	15	(8 – 48)	-5.10		0.00	-10.57	-4.54
Annual Admissions	ICUA	1417	1322	1.01	522.84	.322	97.13	286.43
	ICUB	937		- 4.10		.000	-577.13	-193.58
Annual Volume Per Bed	ICUA	(83)	71	3.22	21.67	.003	3.20	20.50
	ICUB	(62)		-2.17		.038	- 16.40	- 0.50
Annual Occupancy	ICUA	(1.03)	.83	9.54	11.95	.000	16.10	24.90
	ICUB	(.76)		-3.04		.005	-10.90	-2.13
Annual SMR	ICUA	(.79)	.78	.646	9.45	.523	2.37	4.56
	ICUB	(.76)		-1.21		.271	-5.40	-1.56

Notes: 1. (ANZICS CORE 2014b)
2. ANZICS APD Dataset (2013)
3. α = < 0.05

The difference in beds in the conventional ICU was within one standard deviation and was therefore not considered to be clinically significant or an influential confounder. Reflecting the typically larger capacity of the hot-floor model, total bed capacity for the ICU hot-floor was significantly higher than the national mean total of 25 beds ($t_{(30)}$ = 17.19, p = 0.00; 95% CI 22.40 to 28.40). Conversely, the conventional ICU had statistically significantly lower total bed capacity by -7 ($t_{(30)}$ = -5.10, p = 0.00; 95% CI -10.57 to -4.54) consistent with the smaller capacity, stand-alone traditional ICU model.

The ICU hot-floor managed a considerably higher demand in terms of patient admissions and volume, and average unit occupancy. The national mean admission rate was also significantly higher than that of the conventional ICU, which had 385 patients fewer in 2013 ($t_{(30)}$ = - 4.10, p = 0.000; 95% CI – 577.13 to – 193.58). Patient volume per bed annually was significantly higher in the ICU hot-floor by 12 patients ($t_{(30)}$ = 3.22, p = 0.003; 95% CI 4.60 to 20.50) and significantly lower in the conventional ICU by 9 patients ($t_{(30)}$ = -2.17, p = 0.038; 95% CI -16.40 to - 0.50) when compared to the national average. Similarly, mean ICU occupancy was significantly higher in the ICU hot-floor by 20% ($t_{(30)}$ = 9.54, p = 0.000; 95% CI 16.10 to 24.90) and significantly lower in ICUB by 7% ($t_{(30)}$ = -3.04, p = 0.005; 95% CI -10.90 to -2.13).

Access to beds, a summative quality management measure reported by ICUs nationally, indicated that 2.2% of patients were not admitted due to inadequate resources (ACHS 2014). Rates in both the ICU hot-floor and conventional ICU were lower than the reported national average at 0.6% and 0.7% respectively. Admission profiles for both units were also comparable and similar to the national ICU population in nearly all attributes (see Table 5.2).

Table 5.2 Patient admissions

Attribute		Unit P	National P	p [1,2]
Elective Admissions	ICUA	.33	.30	.231
	ICUB	.31		.111
Admission Source OT	ICUA	.31	.33	.168
	ICUB	.32		.192
Admission Source Emergency	ICUA	.30	.27	.054
	ICUB	.26		.211
Admission Source Internal	ICUA	.27	.31	.052
	ICUB	.29		.075
Admission Source External	ICUA	.12	.10	.064
	ICUB	.13		.052
Invasively Ventilated on Admission	ICUA	.39	.42	.067
	ICUB	.59		.000
Gender	ICUA	.42	.39	.092
	ICUB	.39		.480

Notes: 1. $\alpha = < 0.05$
2. Exact test significance (1-tailed)

The proportion of invasively ventilated patients admitted to the conventional ICU was 59%; substantially higher than the ICU hot-floor at 39%, and statistically higher than tertiary ICUs nationally at 42% (p = 0.000, 1-sided). The impact of this finding is considered further in relation to severity of illness measures to evaluate the potential confounding influence of this attribute in the conventional ICU. Comparison of patient casemix demonstrated that for the conventional ICU, median severity of illness was statistically significantly higher than the national population (APACHE III-J score; z = 3.53, p = 0.000; SAPS II; z = 8.10, p = 0.000) (see Table 5.3). However, differences were minimal, within one standard deviation of APACHE III-J (SD + 4.31) and SAPS II (SD + 2.67), reflecting no clinical significance. For the ICU hot-floor, median length of stay (LOS) was statistically significantly higher than the national population by 9.8 hours. (M = 73.50; z = 4.41, p = 0.000), but was also within one standard deviation (SD + 12.7) of the population suggesting limited variance.

Table 5.3 Patient casemix

Attribute	Unit Median		ANZICS Median	z	α[1,2]
Age (yrs.)	ICUA	59.95	60.05	-1.95	.051
	ICUB	62.00		.818	.413
APACHE III-J	ICUA	57.00	56.93	1.80	.072
	ICUB	58.00		3.53	.000
SAPSII	ICUA	34.00	33.60	.317	.751
	ICUB	36.00		8.10	.000
LoS (hours.)	ICUA	73.50	63.70	4.41	.000
	ICUB	58.50		-1.85	.065

Notes: 1. α = < 0.05
2. Asymptotic Sig. (2-sided test)

5.3 Workforce

Workforce structures were similar in both units and unchanged from the 2013 unit profiles previously described in Table 2.4. (see Appendix 17). A snapshot of workforce characteristics per position type, taken in May 2014 (see Appendix 18), revealed the conventional ICU had significantly more RN years three-four (35.0% vs. 29.2%, χ^2= 3.81, $p < 0.001$), while the ICU hot-floor had significantly more RNs years one-two (36.2% vs. 19.4%, χ^2 = -6.47, $p < 0.001$). In contrast, the ICU hot-floor had a lower proportion of nursing management (11.0% vs. 16.0%) and educator positions (1.25% vs. 3.70%) (summary data aggregated at the unit were available and not tested statistically). Similarly, a lower proportion of nurses held an ICU qualification (43% vs. 49%); with both ICUs being slightly lower than the national average of 51%. Shift staffing of clinical bedside nurses during business hours and after-hours was also comparable.

Workforce establishments, compared between units on a quarterly basis throughout the retrospective patient study (1 January 2013 to 31 December 2013) and the prospective nurse survey (1 April 2014 to 30 June 2014) were stable for the duration of this research (see Appendix 19). The medical staff FTE per bed was lower in the ICU hot-floor (1.1/bed vs. 2.3/bed) and below the national average (1.5 FTE/bed). Dedicated pharmacist FTE was also lower (0.35 vs. 1.0 FTE) as was ancillary/orderly support positions (1.35 vs. 3.0 FTE) during business hours and after-hours.

5.4 Patients

5.4.1 Demographic and clinical characteristics

Patients in the two sites were equivalent for age, gender, severity of illness (APACHE III-J), smoking status and admission type (planned vs. unplanned) (see Table 5.4). The ICU hot-floor had a higher proportion of patients identifying as ATSI (3.8% vs. 0%, χ^2= 17.38; p = 0.000) and admissions from external hospital transfers (5.2% vs. 0%, χ^2= 26.7; p = 0.000). The median LoS was also significantly higher (M = 74 vs. 58.5 hours, z = -2.55, p = 0.011). Overall, ICU origin had a small influence on these three unit level variables (***r*** = 0.08 to 0.163).[1] Conversely, patients in the conventional ICU had a significantly higher SAPSII score (M = 37 vs. 34, z = -5.88, p = 0.000) and more were admitted from OT (47% vs. 37%, χ^2= 9.85; p = 0.002), with ICU origin having a small influence (r = 0.099 to 0.19). The higher proportion of invasively ventilated patients in the sample (59% vs. 38.6%, χ^2= 129.6; p = 0.000) was also higher than the national tertiary ICU adult population (59% vs. 42%, p = 0.000, 1-sided), with ICU origin having moderate influence (r = 0.31).

Correlation analysis confirmed that similar relationships existed between age and APACHE III-J, and SAPS II scores (see Appendix 20). Conversely, a significant difference in the strength of the correlations between Age vs. LoS (z = 2.08; two tail p = 0.038), APACHE III-J vs. LoS (z = 6.00; two tail p = 0.00) and SAPSII vs. LoS (z = 6.81; two tail p = 0.00) was evident in each unit. Overall patient samples and study settings were matched on multiple factors, and any potential confounding on patient outcomes was considered limited.

[1] Phi coefficient effect size ranges from 0 to 1 with higher values indicating a stronger association between two variables and the effect size was rated using Cohen’s (1998) criteria of .10 for small effect, .30 for medium effect and .50 for large effect.

Table 5.4 Patient sample characteristics

							Mann-Whitney U			Pearson Chi-Square		
		n	%	Median	IQR	Range	*Z*	α [3]	*r* [4]	$\chi^2_{(df\ 1)}$ [2]	α [3]	*r* [4]
Age (yrs)	ICUA[1]			59.95	26.97	15.20 – 103.3	-.879	.380	0.03			
	ICUB[2]			62.00	25.85	15.90 – 91.40						
Gender (Female)	ICUA	210	42							.701	.403	.029
	ICUB	196	39.2									
APACHE III-J	ICUA			57.00	32.75	7.00 – 172.0	-.934	.350	0.03			
	ICUB			58.00	45.00	11.00 –199.00						
SAPSII	ICUA			34.00	19.00	2.00 - 83.00	-5.88	.000	0.19			
	ICUB			37.00	24.00	2.00 - 107.00						
Planned Admission	ICUA	142	28.4							.080	.778	-.011
	ICUB	137	27.4									
Source: OT admission	ICUA	186	37.2							9.85[7]	.002	.099
	ICUB	235	47.0									
Source: ED admission	ICUA	145	29.0							3.21[7]	.073	-.057
	ICUB	120	24.0									
Source: Int. transfer	ICUA	143	28.6							.020[7]	.889	.889
	ICUB	145	29.0									
Source: Ext. transfer	ICUA	26	5.2							26.69[7]	.000	-.163
	ICUB	0	0									
Ventilated (Invasive)	ICUA	193	38.6							129.56	.000	.313
	ICUB	295	59.0									
LoS (hours.)	ICUA			74.00	79.00	0 – 1460	-2.55	.011	0.08			
	ICUB			58.50	100.00	1.0 - 918						
ATSI	ICUA	19	3.8							17.38	.000	-.139
	ICUB	0	0									
Never smoked	ICUA	96	40.0[5]							.350	.986	.027
	ICUB	107	60.0									

Notes:
1. n = 500 patients
2. Yates continuity correction
3. α = < 0.05, Asymptotic Significance (2 sided)
4. *r* = Phi coefficient
5. Valid % of responses excluding missing data (i.e. ICUA 240/500 (responses) then 96/240 = 0.4)
6. Valid % of responses excluding missing data (i.e. ICUB 251/500 (responses) then 107/251 = 0.426)

5.4.2 Patient outcomes

No differences were evident for three adverse patient events: 1) unplanned extubation (3.2% vs. 2.6%, χ^2 = 0.142; *p* = 0.706); 2) hospital acquired infection (CLABSI) (1.0% vs. 0.8%, χ^2= 0.00; *p* = 1.00); and 3) rate of pressure ulcers (16.2% vs. 13.8%, χ^2= 0.949; *p* =0.330). Unplanned readmission rates were also similar (1.8%% vs. 3.0%, χ^2= 1.07; *p* = 0.302) (see Table 5.5).

Table 5.5 Patient outcomes results

Variable		n (%)		Pearson Chi-Square			
		ICUA	ICUB	χ^{2} [1]	df	α [2, 3]	r [4]
Unplanned Extubation	Yes	16 (3.2)	13 (2.6)	.142	1	.706	-.018
	No	484 (96.8)	487 (97.4)				
CLABSI	Yes	5 (1.0)	4 (0.8)	.000	1	1.00	-.011
	No	495 (99.0)	496 (99.2)				
Pressure Ulcer	Yes	81 (16.2)	69 (13.8)	.949	1	.330	-.034
	No	419 (83.8)	431 (86.2)				
VTEP	Yes	434 (86.8)	489 (97.8)	41.03	1	.000	.206
	No	66 (13.2)	11 (2.2)				
Mortality (Crude)	Died	51 (10.2)	52 (10.4)	.000	1	1.00	-.003
	Survived	449 (89.8)	448 (89.6)				
After Hours Discharge	Yes	97 (19.4)	150 (30.0)	14.54	1	.000	.123
	No	403 (80.6)	350 (70.0)				
Delayed Discharge >6hours	Yes	319 (71.0)	281 (62.7)	6.64	1	.010	-.088
	No	130 (29.0)	167 (37.3)				
Unplanned Readmission<72 hours	Yes	9 (1.8)	15 (3.0)	1.07	1	.302	.039
	No	491 (98.2)	485 (97.0)				

Notes:
1. Yates continuity correction
2. α = < 0.05
3. Asymp. Sig (2 sided)
4. r = phi coefficient

Compliance with evidenced based protocols was evaluated by the rate of Venous Thromboembolism Prophylaxis (VTEP) provided to patients, recognised as a key determinant of patients developing a deep vein thrombosis where not contraindicated. Compliance was significantly lower in the ICU hot-floor (86.8% vs.97.8%, χ^2= 41.03; *p* = 0.000), with ICU origin having low to medium influence (*r* = 0.206).

After-hours discharge, associated with greater risk of an adverse event, was significantly higher for conventional ICU patients (30.0% vs. 19.4%, χ^2 = 14.54; *p* = 0.000), with ICU origin having a small influence (*r* = 0.123). In contrast, patients in the ICU hot-floor had a significantly higher rate of discharge delay (greater than 6 hours) (71.0% vs. 62.7%, χ^2= 6.64; *p* = 0.010), with ICU origin having a similarly small degree of influence (*r* = -0.08).

Patient LoS, previously used to compare study settings, is routinely used as an outcome measure. The ICU hot-floor LoS was significantly higher (*M* = 74 hours. vs. 58.5 hours., z = -2.55, p = 0.011), and again the influence of ICU origin was negligible (*r* = 0.08).

Lastly, in regard to unit volume results, shown previoulsy in Table 5.1, confirmed the hot-floor had a significntly higher annual patient volume per bed and higher mean unit occupancy, than the conventional ICU and national average. However, no significant difference in crude mortality was evident between the two units (10.2% vs. 10.4%, χ^2= 0.00; *p* = 1.00). Similarly, the annual SMR for each unit were approximately equal (SMR = 0.79 hot-floor vs. 0.76 conventional ICU) and close to the national average (SMR = 0.78), despite the higher activity in the ICU hot-floor.

5.5 Nursing staff

5.5.1 Demographic and work characteristics

In total, 145 nurses participated in the study; 82 and 63 for the hot-floor and conventional ICUs, respectively. Four questionnaires were incomplete and not included. Response rates were 73% and 75% respectively, exceeding the estimated sample size required. Nurse characteristics were matched on gender and qualification levels (see Table 5.6).

Overall, 78.6% of the sample was female. The proportion of males in both units (24.4% ICU hot-floor vs. 17.5% conventional ICU) was higher than overall state and national averages, 12% and 15% respectively, reflecting the higher number of males known to work in critical care specialties (AIHW 2013, 2014).

Table 5.6 Nurse demographic characteristics

Characteristic	Variable	ICUA n	ICUA %	ICUB n	ICUB %	Statistic χ^2 [1]	df	α [2, 3]	r [4]
Gender	Female	62	75.6	52	82.5	0.65	1	.421	.220
	Male	20	24.4	11	17.5				
Age (years)	20 – 24	7	8.5	14	22.2	7.14[e]	7	.414	.053
	25 – 29	36	43.9	22	34.9				
	30 – 34	13	15.9	10	15.9				
	35 – 39	7	8.5	4	6.3				
	40 – 44	11	13.4	8	12.7				
	45 – 49	5	6.1	4	6.3				
	50 – 54	2	2.4	0	0.0				
	55 – 59	1	1.2	1	1.6				
ICU Qualified	Yes	46	56.1	32	50.8	0.22	1	.641	.053
	No	36	43.9	31	49.2				
Highest Nursing Qualification	Undergraduate	33	40.2	32	50.8	1.81[5]	2	.405	.112
	Postgraduate	34	41.5	23	36.5				
	Masters	15	18.3	8	12.7				
Highest Non-Nursing Qualification	Nil	43	52.4	34	54.0	0.19[5]	3	.980	.036
	Undergraduate	28	34.1	22	34.9				
	Postgraduate	6	7.3	4	6.3				
	Masters	5	6.1	3	4.8				
Notes:	1. Yates continuity correction 2. α = < 0.05 3. Asymptotic significance (2 sided) 4. Phi coefficient 5. Pearson Chi-square								

Age distribution was the same in each ICU and skewed to the right with the bulk of nurses in the 20 to 39 year range (see Figure 5.1).

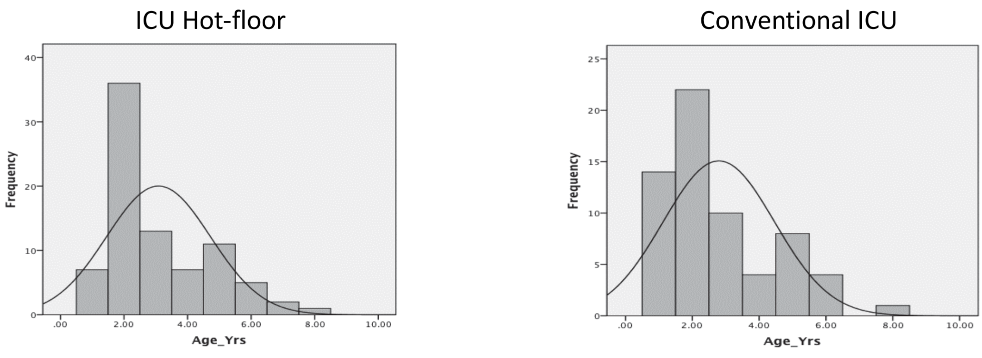


Figure 5.1 Patient age distributions

Nurse factors were matched on years of clinical and specialist intensive care experience, and the proportion of staff working full time (see Table 5.7).

Table 5.7 Nurse work factors

Work Factor	Variable	ICUA n	ICUA %	ICUB n	ICUB %	Statistic χ^2 [1]	df	α [2, 3]	r [4]
Job Title	RN	69	84.1	42	66.7	5.13	1	.014	.205
	CNS	13	15.9	21	23.4				
Years Worked as an RN	< 1	1	1.2	4	6.3	6.65[5]	6	.354	.214
	1 to 2	9	11.0	5	7.9				
	3 to 5	32	39.0	20	31.7				
	6 to 10	17	20.7	20	31.7				
	11 to 15	11	13.4	6	9.5				
	16 to 20	5	6.1	5	7.9				
	> 20	7	8.5	3	4.8				
Years Worked as an RN in ICU	< 1	13	15.9	14	22.2	9.72[5]	6	.159	.253
	1 to 2	19	23.2	10	15.9				
	3 to 5	16	19.5	14	22.2				
	6 to 10	18	22.0	14	22.2				
	11 to 15	11	13.4	6	9.5				
	16 to 20	1	1.2	5	7.9				
	> 20	4	4.9	0	0.0				
Years Worked as an RN in This ICU	< 1	16	19.5	16	24.5	6.60[5]	6	.252	.213
	1 to 2	22	26.8	10	15.9				
	3 to 5	18	22.0	22	34.9				
	6 to 10	18	22.0	9	14.3				
	11 to 15	7	8.5	6	9.5				
	16 to 20	1	1.2	0	0.0				
	> 20	0.0	0.0	0	0.0				
Employment Status	Full Time	72	87.8	57	90.5	0.06	1	.809	-.042
	Part Time	10	12.2	6	9.5				
Shift Pattern	12-hour	47	57.3	20	31.7	8.37	1	.004	.025
	Mixed (8,8,10)	35	42.7	43	68.3				
Frequency Redeployed From ICU	Never	9	11.0	15	23.8	26.3[5]	4	.000	.425
	Rarely	42	51.2	7	11.1				
	Occasionally	25	30.5	31	49.2				
	Frequently	5	6.1	9	14.3				
	Very Frequently	1	1.2	1	1.6				
Paid Overtime Worked	Nil	59	72.0	62	98.4	16.2	1	.000	-.353
	Yes	23	28.0	1	1.6				
Unpaid Overtime Worked	Nil	52	63.4	39	61.9	0.00	1	.990	.015
	Yes	30	36.6	24	38.1				

Notes: 1. Yates continuity correction; 2. α = < 0.05; 3. Asymptotic significance (2 sided); 4. Phi coefficient; 5. Pearson Chi-square

More Clinical Nurse Specialists (CNS) (defined as RNs with relevant post-registration qualifications and at least 3 years experience working in the clinical area of their specified post-graduate qualification) worked in the conventional ICU (23.4% vs. 15.9%, $\chi^2 1 = 5.13$; $p = 0.014$). Nurses were also more likely to be redeployed out of ICU on a shift-by-shift basis with a significantly higher number of responses indicating occasional and frequent redeployment (χ^2_4 = 26.25; *p* = 0.000), with ICU origin having a medium to strong influence (***r*** = 0.425). Conversely, the proportion of nurses working *'Paid Overtime in the Last Week'* was 22% higher in the ICU hot-floor (28%. vs. 6%, χ^2_1 = 16.20; *p* = 0.000; ***r*** = - 0.353), with ICU origin having a medium level of influence.

5.5.2 Nurse outcomes

Nurse perceptions of local management factors and job satisfaction did not differ significantly between the units (see Table 5.8). Nurses in the ICU hot-floor did however rate multiple factors consistently lower, including roster flexibility (poor = 12.2% vs. 6.3%), clinical supervision (fair = 19.5% vs. 9.5%), and access to a clinical educator (fair = 17.12% vs. 11.1%). Differences were compounded by higher demand on bedside nurses in the ICU hot-floor to mentor colleagues (very frequently = 6.1% vs. 0.0%) and provide clinical advice (very frequently = 40.2% vs. 22.0%).

Quality of care, occupational health and safety (OHS) and social cohesion were perceived equally high in both units. Overall positive nurse perceptions were also reflected in high job satisfaction, satisfaction with nursing and low intention to leave rates. While these findings may not infer causality, they do inform interpretation of the results from PES-NWI and MBI ICU nurse survey sections.

Overall, no significant differences were found on a range of demographic and work characteristics, and in relation to work perceptions when explored between groups. The influence of nurse characteristics on perceptions was analysed according to a within groups analysis model (see Appendix 21). Significant factors were similarly reflected within each group (see Appendix 22). Typically, senior nurses provided clinical support to junior nurses. Senior nurses and part-time staff rated quality of care higher. Unpaid overtime decreased job satisfaction, while overall satisfaction with nursing was higher in full time staff. These findings further support the underlying assumption that nurse samples were closely matched, informing the interpretation of outcomes measured by PES-NWI and MBI sections of the ICU nurse survey.

Table 5.8 Work perceptions

Work Perception	Variable	ICUA n	ICUA %	ICUB n	ICUB %	Pearson Chi-square χ^2	df	α [1, 2]	r [3]
Roster Flexibility	Poor	10	12.2	4	6.3	0.35	3	.323	.155
	Fair	18	22.0	18	28.6				
	Good	42	51.2	36	57.1				
	Excellent	12	14.6	5	7.9				
CNE Access	Poor	0	0.0	0	0.0	1.50	2	.373	.102
	Fair	14	17.1	7	11.1				
	Good	43	52.4	32	50.8				
	Excellent	25	30.5	24	38.1				
Level of Supervision	Poor	0	0.0	0	0.0	3.17	2	.205	.148
	Fair	16	19.5	6	9.5				
	Good	54	65.9	44	69.8				
	Excellent	12	14.6	13	20.6				
Required to Mentor Nurses	Never	29	35.4	24	38.1	7.40	4	.118	.225
	Rarely	18	22.0	22	34.9				
	Occasionally	20	24.4	10	15.9				
	Frequently	10	12.2	7	11.1				
	Very frequently	5	6.1	0	0.0				
Required to Provide Clinical Advice	Never	5	6.1	7	11.1	4.02	4	.403	.167
	Rarely	10	12.2	3	4.8				
	Occasionally	12	14.6	11	17.5				
	Frequently	22	26.8	20	31.7				
	Very frequently	33	40.2	22	34.9				
Quality of Care in Past Year	Worked < 1 year	12	14.6	8	12.7	2.14	3	.545	.121
	Deteriorated	11	13.4	5	7.9				
	Remained Same	38	46.3	28	44.4				
	Improved	21	25.6	22	34.9				
Quality of Care Last Shift	Poor	0	0.0	0	0.0	4.50	3	.108	.175
	Fair	2	2.4	1	1.6				
	Good	55	67.1	32	50.8				
	Excellent	25	30.5	30	47.6				
OHS	Poor	1	1.2	0	0.0	2.82	3	.421	.139
	Fair	16	19.5	7	11.1				
	Good	51	62.2	45	71.4				
	Excellent	14	17.1	11	17.5				
Social Cohesion	Poor	3	3.7	6	9.5	4.50	3	.212	.176
	Fair	18	22.0	19	30.2				
	Good	44	53.7	30	47.6				
	Excellent	17	20.7	8	12.7				
Resign < 12 Months	No	57	69.5	52	82.5	2.58 [4]	1	.108	.149
	Yes	25	30.5	11	17.5				
Intend to Move ICUs	No	68	82.9	56	88.9	0.60 [4]	1	.439	.084
	Yes	14	17.1	7	11.1				
Job Satisfaction	Very Dissatisfied	4	4.9	0	0.0	3.54	3	.316	.156
	Little Dissatisfied	11	13.4	7	11.1				
	Moderately Satisfied	46	56.1	37	58.7				
	Very Satisfied	21	25.6	19	30.2				
Satisfaction with Nursing	Very Dissatisfied	2	2.4	0	0.0	2.90	3	.415	.140
	Little Dissatisfied	3	3.7	4	6.3				
	Moderately Satisfied	45	54.9	30	47.6				
	Very Satisfied	32	39.0	29	46.0				

Notes: 1. $\alpha = < 0.05$ 2. Asymptotic Significance (2 sided) 3. ***r* =** phi coefficient 4. Yates Continuity Correction

Mean and median subscale scores of PES-NWI domains are summarised in Table 5.9.

Table 5.9 PES-NWI subscale scores

Subscale	Unit	Mean[1] (SD)	Median	Min	Max[2]	95% CI
Nurse participation in hospital affairs	ICUA	2.8 (0.47)	2.9	1.7	4.0	2.7 – 2.9
	ICUB	2.9 (0.53)	2.9	2.7	3.9	2.7 – 3.0
Nursing foundations for quality of care	ICUA	2.9 (0.44)	2.9	1.9	4.0	2.9 – 3.0
	ICUB	3.1 (0.41)	3.0	2.1	3.9	3.0 – 3.2
Nurse Manager ability, leadership and support	ICUA	2.8 (0.55)	2.8	1.4	4.0	2.7 – 3.0
	ICUB	3.1 (0.50)	3.2	1.6	4.0	3.0 – 3.2
Staffing and resource adequacy	ICUA	2.8 (0.53)	2.8	1.5	4.0	2.7 – 3.0
	ICUB	3.0 (0.57)	3.0	1.8	4.0	2.8 – 3.1
Collegial Nurse-Physician Relations	ICUA	3.1 (0.52)	3.0	1.7	4.0	3.0 – 3.2
	ICUB	3.1 (0.44)	3.0	1.7	4.0	3.0 – 3.2

Notes: 1. Scores above 2.5 indicate agreement that the item is present in the workplace
2. Possible range for all subscales 1 to 4

All subscales scored positively above 2.5 in both units with validity evident in the narrow confidence intervals (Lake & Friese 2006). Nurses in the conventional ICU rated the work environment more positively on four subscales with the '*Collegial Nurse-Physician Relations*' subscale rated equally in both units.

Nurse burnout was initially assessed by MBI subscale categorisation. High burnout was indicated by the frequency of high scores for '*Depersonalisation*' and *'Emotional Exhaustion'* subscales, and low scores for the *'Personal Accomplishment'* subscale.

In the present study, '*Depersonalisation*' and *'Emotional Exhaustion'* were scored low by a majority of nurses from both units while *'Personal Accomplishment'* rated highly in both groups reflecting the results of earlier studies (Guntupalli et al. 2014; Zhang et al. 2013) (see Table 5.10). This suggested a low to moderate degree of burnout in the sample as a whole, though unit differences were evident (see Figure 5.2).

Table 5.10 MBI subscale categorisation [2]

Subscale		ICUA		ICUB	
		N	%	N	%
Depersonalisation (DP)	Low	33	37.8	36	57.1
	Mod	22	26.8	10	15.9
	High	27	35.4	17	27.0
Emotional Exhaustion (EE)	Low	32	39.0	31	49.2
	Mod	23	28.1	16	25.4
	High	27	32.9	16	25.4
Personal Accomplishment (PA)	Low	22	26.8	19	30.2
	Mod	28	34.2	23	36.5
	High	32	39.0	21	33.3

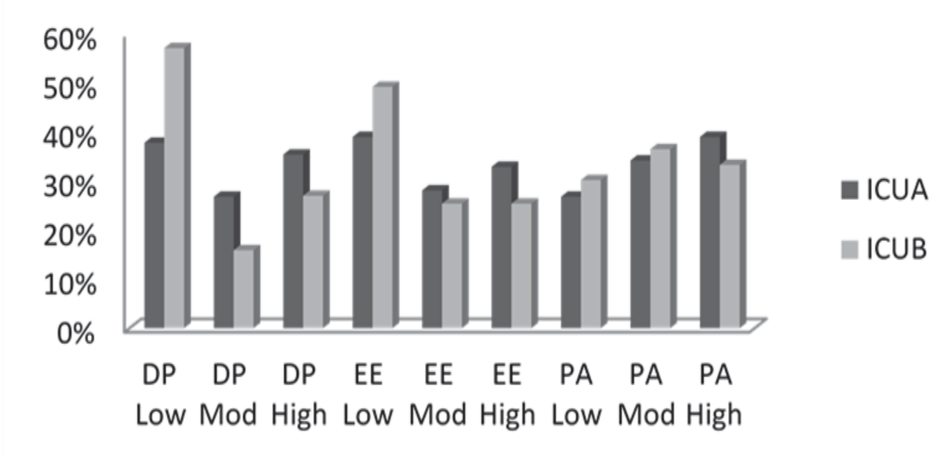


Figure 5.2 MBI subscales score frequencies

A lower level of burnout overall was observed in the conventional ICU with '*Depersonalisation'* rated low by approximately 20% more nurses and *'Emotional Exhaustion'* rated as low by approximately 10%. In contrast, in ICU hot-floor nurses rated their level of *'Personal Accomplishment'* higher by a small margin of approximately 6%.

Descriptive results and measures of central tendency for the MBI subscales are summarised in Table 5.11. Narrow 95% confidence intervals indicate the sample subscale means reflected the true mean value in the study population.

[2] Analysis performed according to the relevant literature (Maslach, Jackson & Leiter 1996b).

Table 5.11 MBI subscale results

Subscale	Unit	N	Mean (SD) [1]	Median	Min	Max	Mean 95% CI
Depersonalisation	ICUA	82	7.45 (4.71)	7.0	0.0	19.0	6.42 – 8.50
	ICUB	63	6.06 (4.73)	5.0	0.0	17.0	4.87 – 7.26
Emotional Exhaustion	ICUA	82	22.28(4.71)	21.50	2.0	52.0	19.8 – 24.8
	ICUB	63	19.14(10.1)	19.00	0.0	45.0	16.6 – 21.7
Personal Accomplishment	ICUA	82	34.55(6.40)	36.00	21.0	46.0	33.1 – 36.0
	ICUB	63	36.14(6.38)	36.00	18.0	47.0	34.5 – 37.8

Notes: 1. Normative sample scores Mean (SD): DP = 7.12 (5.22), EE = 22.19 (9.53), PA = 36.53 (7.34) (Maslach, Jackson & Leiter 1996a)

Descriptive results for the PES-NWI previously reported in Table 5.9 and those for the MBI, reported above in Table 5.11, were used to test the psychometric properties of survey instruments used and validate their selection for this study. The results addressed research question No. 2 *'What nurse outcomes are mediated by organisational factors in the work environment, and which instrument best measures the outcomes in ICU?'* Both PES-NWI and MBI subscales demonstrated good internal consistency and reliability. Cronbach's alpha scores for PES-NWI subscales ranged from 0.74 to 0.83 with an overall score of 0.92, while MBI scores ranged from 0.62 to 0.91 and 0.76 overall (see Table 5.12).

Table 5.12 Cronbach's alpha scores

	Subscale	α
PES-NWI	Participation in Hospital Affairs	0.83
	Nursing Foundations for Quality of Care	0.75
	Nurse Manager Ability, Leadership, and Support of Nurses	0.76
	Staffing and Resource Adequacy	0.74
	Collegial Nurse- Physician Relations	0.78
	Overall PES-NWI	0.92
MBI	Depersonalisation (DP)	0.62
	Emotional Exhaustion (EE)	0.91
	Personal; Accomplishment (PA)	0.69
	Overall MBI	0.76

Principal Component Analysis (PCA) coefficients were higher than 0.3 for both scales (see Appendix 23). The Kaiser-Meyer-Olkin value exceeded 0.859 for PES-NWI and 0.854 for MBI, higher than 0.6 with a statistically significant Bartlett's test of sphericity (p = 0.000), indicating both scales were suitable for factor analysis of the correlation matrix.[3] In addition the ratio of respondents to items was 5:1 for PES-NWI and 7:1 for MBI further supporting suitability for factor analysis (Tabachnick & Fidell 2013).

The initial PCA confirmed both scales had Eigenvalues greater than one with the five components of PES-NWI explaining 31.26%, 6.35%, 6.14%, 5.21% and 4.74%, of variance. The MBI components explained 30.74%, 11.04% and 8.33%. Results indicated five and three factor models respectively, reinforced by scree plots for each scale (see Appendix 24) (Catell & Vogelmann 1977).

Confirmatory Factor Analysis (CFA) confirmed the presence of five and three components respectively, with Eigenvalues exceeding the corresponding criterion values for randomly generated data matrices of the same size i.e. 30 (PES-NWI) or 22 (MBI) items and 145 respondents.[4] Varimax rotation also confirmed the five-factor and three-factor structures with strong factor loading coefficients exceeding 0.3 (see Appendix 25). The total variance explained by the models was 53.7% and 50.11% for the PES-NWI and MBI, respectively (see Appendix 26), consistent with an earlier similar study (Klopper et al. 2012). Finally, all major indices generated with the CFA confirmed that both the five-factor and three-factor models had acceptable fit to the data (see Appendix 27). Both PES-NWI and MBI demonstrated good reliability and internal consistency, providing confidence that the organisational practice environment could be effectively assessed.

Normality assumptions were then tested to confirm the appropriate statistical analysis. On visual examination, the majority of subscales for the PES-NWI and MBI appeared to be normally distributed (see Appendix 28). The MBI_PA subscale demonstrated a mild negative skew in the ICUB group, the significance of which is explored statistically later in this section. Distributions were peaked and narrow about the mean for both groups across all subscales reflecting a

---

[3] 3.0 is minimum and > 0.4 is an important correlation, and if only a few coefficients are above 3.0 then factor analysis may not be suitable (Poghosyan, Aiken & Sloane 2009; Tabachnick & Fidell 2013).
[4] Parallel Analysis was performed using the Monte Carlo PCA software (http://rankingz.org/windows/apps/post/11073/Monte-Carlo-PCA-for-Parallel-Analysis) a standalone Windows program that computes Parallel Analysis criteria (eigenvalues) to determine the number of factors to retain in a factor analysis (Rosenthal 2000; Watkins 2000)

‘mesokurtic’ pattern and suggesting a high level of agreement and good representation of the nurse population studied. Boxplots revealed both samples were relatively homogenous across all subscales with only a small number of non-extreme outliers that fell within range of the original data set. The PES-NWI *‘Collegial Nurse-Physician Relations’* subscale displayed several extreme outliers indicating lesser agreement on the presence of this characteristic in the practice environments of both units.

Normality assumption statistical tests however produced some inconsistent results (see Appendix 29). Subscale histograms, assessment of the 5% trimmed mean, evaluation of skewness, kurtosis and Normal Q-Q Plots confirmed approximate symmetry in four out of five PES-NWI subscales and two of three MBI subscales. The PES-NWI *‘Collegial Nurse-Physician Relations’* and MBI ‘*Depersonalisation’* subscales were moderately skewed in both groups, confirmed by significant kurtosis, Kolmogorov-Smirnov and Shapiro-Wilk values. However, sample means and medians were approximately equivalent and small standard deviations in all subscales indicated the degree of asymmetry was negligible. Furthermore, the skewness z statistic indicated an approximately symmetrical distribution, and the assumption of approximate normality was therefore upheld, enabling parametric analysis to proceed.

5.5.3 Outcome and work environment associations

Moderately strong positive linear correlations between all PES-NWI subscales and two of three MBI subscales were confirmed by scatterplots and corresponding correlation coefficients (see Appendix 30).[5] The *depersonalisation* and *emotional exhaustion* subscales had weak negative correlations with the *personal accomplishment* subscale suggesting that as *depersonalisation* increased the level of *emotional exhaustion* increased while the sense of *personal accomplishment* decreased, predisposing nurses to burnout. In both groups of nurses a moderate negative correlation was evident between PES-NWI subscales and MBI *depersonalisation* and *emotional exhaustion* subscales, suggesting that as the practice

[5] Strength of the correlation was ranked according to a scale of small (r= 0.10 to 0.29), moderate (r= 0.30 to 0.49) and strong (r= 0.50 to 1.0) (Pallant 2013; Tabachnick & Fidell 2013)

environment improves the level of burnout decreases. Similarly, correlation coefficients suggested that increased *personal accomplishment'* reduced factors associated with burnout.

The presence of an able nurse manager that provided strong leadership and support had a moderate negative correlation with lower levels of *emotional exhaustion* in the ICU hot-floor and *depersonalisation* in the conventional ICU. A similar relationship was also found between *staffing and resource adequacy* and levels of *emotional exhaustion* in both units, and the sense of *depersonalisation'* in the conventional ICU. A moderate negative correlation between *collegial nurse-physician relations* and *emotional exhaustion* was evident in both nursing groups. In the ICU hot-floor better *collegial nurse-physician relations* was also correlated with reduced *depersonalisation*. In both nurse groups, a higher level of *personal accomplishment* was positively correlated with better *collegial nurse-physician relations.*

Dispersion of variables in scatterplots for PES-NWI subscales indicated strong internal construct validity, while broader dispersion observed in MBI subscales suggests weaker construct validity, except between *depersonalisation* and *emotional exhaustion* subscales. Overall, the shape and distribution of correlated subscale pairs confirmed homoscedasticity. The correlation coefficients for PES-NWI and MBI subscales were significant in over 70% of tests in both groups suggesting the presence of primarily moderate strength relationships between subscales. Coefficient z-scores confirmed that PES-NWI and MBI subscales explained similar variation and direction of the relationships for both groups (see Appendix 31).

Underlying general assumptions regarding appropriate level of measurement, independence of observations, normal distribution and homogeneity of variance were previously established. This permitted an independent *t*-test to compare mean PES-NWI and MBI subscale scores between the two groups of nurses (see Table 5.13).

Results confirmed variances were equal in both groups. A significant difference was observed in the mean PES-NWI *nurse manager ability, leadership and support of nurses* subscale which scored lower in the ICU hot-floor ($\bar{x}$ = 2.83, SD = 0.56) than the conventional ICU ($\bar{x}$ = 3.10, SD = 0.50; t_{143} = - 3.03, p = 0.003, two-tailed). The magnitude of the difference in means (mean difference = - 0.27, 95% CI: -0.45 to -0.094) was moderate (eta squared = 0.06) (Cohen 1998).

Table 5.13 Comparison of mean scores for PES-NWI and MBI subscales

	Levene's Test		*t*-test for Equality of Means[1]					95% CI	
	F	Sig.[2]	*t*	df	Sig.[3]	Mean Difference	Std. Error Difference	Lower	Upper
PES_PAR	1.43	.234	-.303	143	.763	-.025	.083	-.189	.139
PES_FOU	.117	.732	-1.49	143	.137	-.107	.071	-.247	-.034
PES_MAN	.332	.565	-3.03	143	.003	-.27	.089	-.447	-.094
PES_RES	1.89	.171	-1.40	143	.165	-.129	.092	-.311	-.053
PES_COL	1.99	.161	.068	143	.946	.006	.081	.055	.166
MBI_DP	.027	.870	1.76	143	.081	.280	.158	.035	.590
MBI_EE	.927	.337	1.73	143	.086	.349	.201	.049	.747
MBI_PA	.817	.368	-1.47	143	.144	-.199	.136	-.467	-.069

Notes: 1. Equal variances assumed.
2. α = < 0.05
3. 2-tailed

Notably, *'Nurse Manager Ability, Leadership and Support of Nurses'* accounted for 60% of variance in the practice environment in both sites. No statistical difference between ICU nurse groups was observed in relation to other organisationally mediated practice environment factors or burnout.

To understand if nurse characteristics and work factors mediated the association between the ICU organisational work environment and nurse outcomes multivariate analysis (MANOVA) was conducted following confirmation of multivariate normality by assessment of Mahalanobis distances (see Appendix 32). Significant results from separate MANOVA tests for PES-NWI and MBI, stratified by demographic and work factors, are reported in Table 5.14 (see Appendix 33 for complete results and accompanying explanation note 1).

Significant differences were identified between ICU nurse groups on six demographic and work factors. To determine the affected subscale, univariate analysis was performed through two-way ANOVA with Tukey's *post-hoc* tests where appropriate (see Appendix 34).

The level of *non-nursing qualification* influenced PES-NWI between units at the composite level (F [15,405] =1.74, p = 0.041; Pillai's Trace = 0.182, partial eta squared = 0.061). However, no univariate subscale was found to be significantly different between groups.

Table 5.14 Significant results following MANOVA

	Instrument	Multivariate Wilk's Lambda		Multivariate Pillai's Trace			Univariate Between-Subjects Effects			
		F	Sig	F	Sig.	Partial Eta Sq.	Subscale	F	Sig.	Partial Eta Sq.
Highest Non-Nursing Qual.	PES-NWI			1.74	.041	.061				
	MBI									
Level of Supervision	PES-NWI									
	MBI	3.17	.005			.065	MBI_PA	4.03	.020	.055
Quality of Care in Past Year	PES-NWI			1.88	.032	.063	PES_PAR	4.35	.006	.087
	MBI									
OHS	PES-NWI									
	MBI			2.27	.037	.047	MBI_DP	2.99	.054[1]	.041
Resign < 12 months	PES-NWI									
	MBI			2.72	.047	.055	MBI_DP	5.85	.017	.040
Satisfaction with Nursing	PES-NWI			2.10	.025	.072	PES_PAR	4.26	.016	.058
	MBI									

1. Close to significance within the significant multivariate model

The only variable of note, and close to significance, was the *collegial nurse-doctor relations* subscale - nurses with a Master level non-nursing qualification in the ICU hot-floor rated the level of collegiality substantially higher (x̄ = 3.13, *SD* = 0.22, CI 95% 2.71 – 3.56) than nurses in the conventional ICU (x̄ = 2.80, *SD* = 0.28, 95% CI 2.23 – 3.33), (F [3,145] = 2.50*,* p = 0.062; partial eta squared = 0.052). This factor was excluded from further analysis due to no statistical significance.

Composite MBI results indicated a statistically significant difference in *intent to resign within 12-months* (F [3,139] = 2.72*,* p = 0.047; Pillai's Trace = 0.055; partial eta squared = 0.06). Nurses in the conventional ICU who intended to resign reported a higher level of burnout due to *depersonalisation* (x̄ = 1.86, *SD* = 1.18) than those in ICUA (x̄ = 1.39, *SD* = 0.75), (F [1,141] = 5.85, p = 0.017), with ICU origin having a small influence reflected by 4.0% of variance in *depersonalisation* being associated with *intent to resign within 12-months* (partial eta squared = 0.04). Due to this variable having only two response levels, *'Yes'* or *'No'*, it was not suitable for Tukey's *post hoc* analysis (Field 2013). The remaining four variables with a significant association with the composite scores for PES-NWI or MBI had three or more levels permitting follow-up analysis.

Perceived *level of supervision* in relation to composite MBI were significantly different between units (F [6,274] = 3.17*,* p = 0.005; Wilks' Lambda = 0.875; partial eta squared = 0.07). Univariate analysis revealed that *personal accomplishment* was lower in the ICU hot-floor when associated with the level of clinical supervision they received (x̄ = 4.32, *SD* = 0.82), when compared to the conventional ICU (x̄ = 4.52, *SD* = 0.80), (*F* [2,139] = 4.03, *p* = 0.020), with ICU origin having a small influence as reflected by 6.0% of variance in *personal accomplishment* being associated with *level of supervision* (partial eta squared = 0.06). For two-way ANOVA, participants were divided into three groups according to their clinical supervision rating (Group 1: Fair; Group 2: Good; and Group 3: Excellent). The interaction between ICU site and clinical supervision rating was statistically significant (*F* [2,139] = 4.03, *p* = 0.02) along with the main effect for level of supervision (*F* [2,139] = 8.20, *p* = 0.00). *Post hoc* testing indicated that the mean MBI_PA score for the fair rating group (x̄ = 4.0, *SD* = 0.95) was significantly lower (*p* =0.002) than the excellent rating group (x̄ = 4.80, *SD* = 0.74). The main effect for ICU site (*F* [1,139] = 0.159, *p* = 0.691) was however not significant, inferring that personal accomplishment and level of clinical supervision were associated, but the ICU nurses' workplace was not a significant influence.

Nurse-rated *quality of care in the past year* measured by the composite PES-NWI was significantly different between groups (*F* [15,405] = 1.80, *p* = 0.032; Pillai's Trace = 0.188; partial eta squared = 0.06). Univariate analysis revealed that *nurse participation in hospital affairs* was associated with nurses' *quality of care* ratings (*F* [3,137] = 4.35, *p* = 0.006), with ICU origin having a small influence (partial eta squared = 0.09). Those nurses in the conventional ICU who believed the quality of care had deteriorated reported a lower level of *participation in hospital affairs* (x̄ = 1.87, *SD* = 0.17) than nurses in the ICU hot-floor (x̄ = 2.56, *SD* = 0.29), again with ICU origin having a small influence as reflected by 9.0% variance in participation being associated with quality of care. The two-way ANOVA divided participants into four groups according to their quality of care rating; 1) worked < 1 year; 2) deteriorated; 3) remained the same; and 4) improved. The interaction between ICU site and quality of care rating was statistically significant (*F* [3,137] = 4.35, *p* = 0.06) and there was a statistically significant main effect for quality of care (*F* [2,137] = 17.12, *p* = 0.00), with ICU origin having moderate influence (partial eta squared 0.27). *Post hoc* test results indicated that the mean PES-NWI participation score (x̄ = 2.34, *SD* = 0.42) in the group that thought quality of care had deteriorated was significantly lower (*p* = 0.000) than the group rating an improvement in quality of care (x̄ = 3.03, *SD* = 0.51). The main effect of ICU site did not reach statistical significance (*F* [1,137] = 2.89, *p* = 0.092) inferring that nurse participation in hospital affairs influences quality of care ratings but the ICU in which nurses worked did not significantly influence the relationship.

Nurse rated level of *occupational health and safety* measured by the composite MBI was significantly different between groups (*F* [6,274] = 2.27, p = 0.037; Pillai's Trace = 0.095; partial eta squared = 0.05). Univariate analysis revealed that *depersonalisation* was associated with levels of *occupational health and safety* (*F* [2,138] = 2.99, p = 0.054). Though not statistically significant the *p-value* was very close to alpha, warranting further exploration. Nurses in the conventional ICU who believed there to be an excellent level of *occupational health and safety* reported lower levels of *depersonalisation* ($\bar{x}$ = 0.47, *SD* = 0.35) than nurses in the ICU hot-floor ($\bar{x}$ = 1.43, *SD* = 0.94). Consistent with other significant differences found, ICU origin had a small influence as reflected by 4.0% variance in *depersonalisation* being associated with the level of *occupational health and safety* (partial eta squared = 0.04). *Post hoc* tests were not performed because at least one group had fewer than two cases.

Finally, *satisfaction with nursing* measured by composite PES-NWI was significantly different between nurse groups (*F* [10,270] = 2.10, p = 0.025; Pillai's Trace = 0.144; partial eta squared = 0.07). Univariate analysis revealed that *nurse participation in hospital affairs* was associated with the overall *satisfaction with nursing* (*F* [3,138] = 4.26, p = 0.016). Those nurses very satisfied with nursing in the conventional ICU also reported higher *participation in hospital affairs* ($\bar{x}$ = 3.15, *SD* = 0.40) than nurses in the ICU hot-floor ($\bar{x}$ = 2.91, *SD* = 0.53). Again ICU origin had a small influence with 6.0% of variance in participation being associated with the level of *satisfaction with nursing* (partial eta squared = 0.06). Also of note were several responses from the ICU hot-floor indicating they were *very dissatisfied* with a correspondingly lower level of *participation in hospital affairs* ($\bar{x}$ = 2.17, *SD* = 0.71) compared to the total mean score for participation ($\bar{x}$ = 2.83, *SD* = 0.47) for all levels of satisfaction. No nurses in the conventional ICU reported they were very dissatisfied.

The two-way ANOVA divided nurses into four groups according to satisfaction rating; 1) very dissatisfied; 2) a little dissatisfied; 3) moderately satisfied; and 4) very satisfied. The interaction between ICU site and s*atisfaction with nursing* was statistically significant (*F* [3,138] = 4.26, p = 0.016, partial eta squared = 0.06) and there was a statistically significant main effect for satisfaction with nursing (*F* [3,137] = 7.46, p = 0.00; partial eta squared 0.14). *Post hoc* tests indicated the mean PES-NWI participation score for the moderately satisfied group ($\bar{x}$ = 2.72, *SD* = 0.44) was significantly lower than the very satisfied group ($\bar{x}$ = 3.02, *SD* = 0.49; p = 0.001). The main effect for ICU site (*F* [1,138] = 0.009, p = 0.924) did not reach statistical significance inferring that *nurse participation in hospital affairs* is positively associated with *satisfaction with nursing* but the ICU in which nurses worked did not significantly influence the relationship.

6 DISCUSSION

6.1 Introduction

Organisational factors in ICU are considered to have great potential to influence patient outcomes (Sakr et al. 2015). Studies examining ICU organisational factors have primarily investigated interventions such as 24-hour Intensivist presence, nurse staffing levels, unit rounding practices, care bundles, targeted training and closed vs. open models. However, no investigation of the hot-floor model, a hybrid organisational model that combines both closed pods of beds and open pods under a single management structure, has been undertaken.

Benefits of the hot-floor model have not been tested and are only assumed to include more efficient demand management, improved resource utilisation, cost containment and the creation of a healthy work environment for nurses and patients (AHIA 2014). This study therefore sought to confirm if the proposed efficiency and effectiveness benefits were realised, and whether inherent structural characteristics and operational processes had an impact on outcomes for nurses and patients (Costa & Kahn 2016; Moss et al. 2016a). Confirmation of the proposed benefits would indicate the hot-floor fulfilled fundamental requirements of a highly reliable organisational and sustainable model critical care services into the future (Fink 2015; Reddy & Guzman 2015; van der Sluijs et al. 2017).

Intensive care has evolved within the last five decades as a clinical support specialty with a distinct organisational model represented by the conventional standalone ICU. Progressive consolidation of these units has seen the emergence of large capacity hybrid (integrated closed and open model) hot-floor services. Though considered controversial due to a perceived loss of triage control (Seppelt 2013), from an organisational perspective the model is considered to better assure access for surgical sub-specialities with high volume postoperative ICU requirements and a responsive service for unplanned demand. The shift away from the closed model of care towards the hybrid 'mega ICU' model presents challenges for staffing and continuity of care (Matlakala, Bezuidenhout & Botha 2014b; Seppelt 2013). Success of the model relies on proactive planning for structural and workforce changes that support effective operational flexibility and contingency, and professional collaboration across multiple clinical specialties on therapeutic management, clinical goals and patient outcomes. Structural prerequisites, operational processes and evidence based clinical practices are clearly defined for conventional ICUs and recognised internationally. The standards provided the basis for comparison of the different ICU models investigated in this study, which were otherwise matched on service level characteristics, patient case-mix and clinical workforce structures.

Integrative literature reviews of high quality empirical studies were required to identify appropriate outcome measures for comparison to address research question one i.e. '*What outcome measures, specific to critically ill patients, are mediated by organisational factors?*'. Eight variables encompassing patient outcomes and unit level effectiveness measures were identified. Pressure injury, CLABSI, unplanned extubation and mortality rates represented patient outcomes shown to be directly associated with organisational factors (Dodek et al. 2015; Soares, Kahn, et al. 2015; Timmers, Hulstaert & Leenen 2014). Unit level measures were VTEP compliance, after-hours discharge, delayed discharge and unplanned readmission, all of which have been found to be detrimental to patient outcomes and increase the risk of an adverse event (Frankel & Moss 2014; Gantner et al. 2014; Weissman et al. 2015).

Research question two sought to determine '*What outcome measures, specific to ICU nurses, are mediated by organisational factors and what is an appropriate survey instrument?*'. Twenty-one nurse outcomes were identified (see Table 3.9) which led to the PES-NWI and MBI-HSS instruments being selected to assess the work environment (Abbenbroek, Duffield & Elliott 2014b; Stalpers et al. 2015a; Van Bogaert et al. 2017). Both instruments demonstrated strong psychometric properties in the ICU context, providing evidence to support their use in future studies.

The outcomes identified for patients and nurses, along with unit level activity measures enabled evaluation of the hot-floor model compared to the conventional ICU on organisational efficiency and effectiveness. Research question three addressed the assumption of improved efficiency by seeking to determine *'Is the closed (hybrid) hot-floor model capable of improving the management of intensive care demand?'*. Overall, the hot-floor was more efficient in terms of patient throughput with relatively higher activity, comparable access to beds and reduced premature patient discharges. However, as a consequence of high patient volume and unit occupancy, and associated increased staff workload, the clinical work environment may have exposed patients and nurses to greater risk of experiencing adverse outcomes.

Research question four prompted the investigation of '*Do hot-floor patient outcomes differ to those in a conventional ICU including the patient volume and mortality association?*'. Patient outcomes were not adversely affected though lower rates of VTEP compliance exposed them to greater risk of deep vein thrombosis and may suggest lower compliance with protocol driven standardised care more broadly. For nurses, research question five explored if *'….the hot-floor model work environment influenced nurse outcomes?'*. Nurses reported lower support and supervision that could be attributed to lower resourcing of front-line management and education positions. Associated with this finding were less effective nursing management and a lower level of personal accomplishment reported by hot-floor nurses. Also notable was that hot-floor nurses consistently reported less satisfaction with the practice environment and a higher propensity for burnout.

For the high-risk hot-floor environment to have high organisational reliability a balance between clinical quality, patient safety and operational contingency is required. The subsequent operational responsiveness and organisational resilience achieved supports the organisational goals of the ICU. For the hot-floor this means providing critically ill patients access to high quality care, despite demand pressures, within a healthy work environment that promotes staff empowerment and positive outcomes. The following discussion of study findings takes this interrelationship and the relevant literature into consideration, to determine if the hot-floor model fulfils HRO requirements. In particular key HRO qualities of operational sensitivity, organisational resilience, a healthy work environment, clinical safety and appropriate resourcing are explored. Limitations, particularly relating to patient heterogeneity and strengths of this study design are the identified to inform the interpretation and generalisability of findings. To address question six, implications and recommendations are then proposed for health service policy, planning, management and future research.

6.2 Hot-floor model organisational reliability

High reliability organisations possess features that promote safety including standardised processes, checklists, operational contingencies, knowledgeable leadership and collaborative multi-disciplinary teams that openly communicate (Padgett et al. 2017). The purpose of these is to balance service delivery efficiency with effectiveness to reliably achieve organisational goals, minimise operational risk, build a safety culture and optimise outcomes (Shabot et al. 2013).

These qualities are encapsulated by the holistic patient paradigm of the ICU team which strives for evidence based best practice that is continually evaluated and tailored for optimal patient outcomes, while meeting the service delivery goals of the organisation (Christianson et al. 2011). Both units displayed these qualities but the hot-floor demonstrated superior organisational, operational and systems integration, fundamental for high performance (Ravitz & Pronovost 2015) though the increased risk of adverse outcomes undermined its organisational reliability.

In relation to demand management this study found that the hot-floor model achieved more efficient patient throughput across multiple unit level measures. Patient throughput was 50% higher with no impediment to patient access to an ICU bed evident. Both units had similar access with an admission refusal rate below 1% comparing favourably with the national rate of 2.2% and considerably less than refusal rates reported internationally, between 17.6 to 42% (Leung, Wong & Gomersall 2016), in high-income countries. The hot-floor achieved this despite higher bed utilisation suggesting the model had superior operational contingency (Harris, Singer, et al. 2015; Naser et al. 2016). Key benefits include reduced need for those patients refused admission to undertake a high-risk inter-hospital transfer (Liu, Kipnis, et al. 2012) and avoiding delays accessing definitive care. Early access and ICU intervention improves patient outcomes with Churpek et al. (2013) finding in a cohort study of 50,032 admissions that for each hour delay there was a 7% increase in the odds of ICU mortality.

Good access and high patient throughput was achieved despite the median unit length of stay (73.5 hours) being 10 hours longer than the conventional ICU (10 hours) and 15 hours longer than the national average. Prolonged ICU stay can impede new admission access, but as this was not evident indicated the hot-floor provided effective internal operational contingency. Furthermore, increased length of stay in ICU is associated with increased risk of an adverse event such as a hospital-acquired infection (Chacko et al. 2017), though this was not evident as indicated by the equivalent CLABSI rates (1%) in both units reflecting best practice.

Contributing to a longer unit stay was a greater proportion (10%) of hot-floor patients experiencing a discharge delay of greater than six hours. Discharge delay is not typically regarded as a positive operational metric and usually relates to hospital wide bed availability (Hobson & Bihorac 2015) and other hospital-level factors that have been reported in 22-67% of discharges (Peltonen et al. 2015). However, the hot-floor continued to manage demand and maintain patient throughput while accommodating higher discharge delay. The integrated service model, incorporating clustered 'step-down' or 'intermediate care' beds, provided effective contingency to accommodate patient discharge delays (Nguyen, Wunsch & Angus 2010a; Vincent & Rubenfeld 2015). This could be attributed to greater variation in nurse:patient ratios made possible by closer alignment of staff allocation to patient acuity, dependency and clinical risk, thereby enhancing the flexibility of the available bed capacity (Town et al. 2014). Additionally, more ready access to the integrated step down areas improves continuity of care for patients transitioning out of ICU (Bennett 2015; Wunsch et al. 2014) while releasing ICU beds for critical admissions.

Higher hot-floor discharge delay may have also contributed to a proportional reduction (10%) in after-hours discharge, that has been shown to be associated with reduced unplanned readmissions due to delayed detection of clinical deterioration (Azevedo et al. 2015; Elliott, Worrall-Carter & Page 2014; Kramer, Higgins & Zimmerman 2013). The large integrated flexible bed base provides an opportunity to retain patients where the transfer would have occurred after-hours (between 6pm and 6am) (Azevedo et al. 2015; Iapichino et al. 2005) avoiding premature discharge (Soltani et al. 2015). This is particularly significant when patients are outliers in wards (Wood, Coster & Norman 2014) during periods of reduced ward staffing levels and clinical supervision. However, the known association between after-hours discharge and unplanned readmission to ICU (Ouanes et al. 2012) was not evident in this study. Hot-floor and conventional ICU readmission rates were 1.8% and 3.0% respectively, despite higher after-hours discharge in the conventional ICU. Issues contributing to unplanned readmission to ICU are multifactorial, from a patient's propensity for deterioration through to hospital wide organisational attributes limiting any assumptions of causality (Bice 2016; Santamaria et al. 2016). Avoiding after-hours discharge, however, continues to be recognised as best practice (Nates et al. 2016).

Research question three, *'Is the closed (hybrid) hot-floor model capable of improving the management of intensive care demand?'* was addressed though these findings. Through combined efficiency and no detriment to patient outcomes, the hot-floor demonstrated effective operational contingency within a safe clinical environment that indicated *organisational resilience*, a core principle of high reliability (Niedner, Muething & Sutcliffe 2013). Furthermore, the ability to respond to constantly changing organisational conditions such as unplanned demand, absorb patient flow delays and balance with the available bed capacity and clinical workforce indicates situational awareness. This suggested the model was able to facilitate *sensitivity to operations,* a second HRO principle (Christianson et al. 2011).

However, greater patient throughput was also associated with high average unit occupancy 103% that indicated the hot-floor routinely operated over census and well above the conventional ICU (76%) and the national average (83%). This contradicts earlier recommendations that occupancy be maintained at 75% (Halpern 2011; Reddy et al. 2015; Tierney & Conroy 2014) and justified as a requirement for optimal patient throughput, an effective response to peak demand and to maintain a safe and healthy work environment. Patients are at greater risk of experiencing an adverse event with high unit occupancies (Eriksson et al. 2017; Tanaka & Ramaiah 2014), including hospital acquired infections, premature discharge and higher mortality (Chrusch et al. 2009; Iwashyna, Kramer & Kahn 2009; Kong et al. 2011), though these were not evident in the hot-floor as previously discussed. Furthermore, crude mortality (10.2%) did not differ from the conventional ICU (10.4%) with a similar risk adjusted SMR of 0.79 and 0.76 respectively, and equivalent to the mean national SMR 0.78. Sustaining quality care in a high risk environment is attributed to a commitment to standardised evidence based best practice (Hasibeder 2010) and this fulfils a third HRO principle, *deference to expertise*, where pathways and protocols support routine processes (Padgett et al. 2017).

Due to greater throughput patient volume (83 admissions per bed annually) was 25% higher than the conventional ICU (62 admissions per bed annually) and 15% higher than the national average (71 admissions per bed annually). Procedural volume is a strong positive predictor of patient outcomes (Darmon et al. 2011; Shuhaiber, Isaacs & Sedrakyan 2015) though a causal relationship is difficult to attribute in ICU due to patient heterogeneity and multiple simultaneous interventions (Phillips et al. 2017). Reduced patient mortality has been demonstrated in high volume ICUs with occupancy rates ranging from 75% to 85% (de Lange, Wunsch & Kesecioglu 2015; Peelen et al. 2007). However, evidence is equivocal with the association between volume and mortality not consistent across all patient groups (Abbenbroek, Duffield & Elliott 2014a; de Lange, Wunsch & Kesecioglu 2015; Sasabuchi et al. 2015). However, highly complex and ventilated critically ill patients admitted with sepsis, multi-organ failure and multi-trauma, for example, are likely to benefit (Nguyen et al. 2015). As a tertiary level ICU, the hot-floor provides the most complex regimen of simultaneous potentially hazardous therapies and organ support modalities at the point of care. No detriment to mortality or other outcomes, such as unplanned extubation or pressure injury, suggests high complexity benefits from volume. However, when combined with high occupancy and intense clinical workload, the organisational reliability of the hot-floor is put at risk.

This finding, in combination with the other outcomes measured, addressed research question four; '*Do hot-floor patient outcomes differ to conventional ICUs and is the volume-mortality association influenced by the demand management changes?'* Patient outcomes did not differ despite greater throughput demonstrating a reliable patient care environment where problems were anticipated, detected and responded to promptly. As such, adverse events resulting in poor patient outcomes may have been averted. While this was also evident in the conventional ICU, the hot-floor also efficiently managed considerably higher demand and overall activity. Therefore, in both units, an HRO principle requiring a *preoccupation with failure* where clinical staff were vigilant to small changes and altered clinical management goals accordingly, was fulfilled (Chassin & Loeb 2013).

The combined high patient volume and turnover, unit occupancy and the high frequency of interdependent tasks increases the risks quality of care and predisposes nurses to dissatisfaction and burnout (Norris, Currie & Lecko 2012). The effect of an intense physical, technically complex and emotionally demanding work environment is amplified by unit congestion due to occupancy leading to fatigue that puts both nurses and patients at risk (Pastores 2015). A workload 'tipping point' may be reached (Momennasab et al. 2017) that is detrimental to both patient and nurse outcomes (Halpern 2011; Howell 2011; Zimmerman 2009). This supports the notion of a high volume threshold where workload may exacerbate operational and staff fatigue manifested by reduced compliance with clinical processes (Abbenbroek, Duffield & Elliott 2014a). A window of optimal ICU organisational performance may exist between low and high volumes, but as yet this not been unequivocally confirmed.

In this study the hot-floor compliance with the VTEP protocol was 86.6%, 11% lower than the conventional ICU, increasing the risk for an adverse patient event and critical deterioration (Yerramilli et al. 2016). Comparatively a point prevalence study of 50 Australian ICUs found national VTEP compliance to be 96%, similar to that of the conventional ICU (Hewson et al. 2011). Internationally, ICU compliance rates vary considerably; from 68% in South Korea (Lee et al. 2014), 77% in the US (Restrepo, Jameson & Carroll 2015), 81% in Spain (García-Olivares et al. 2016) and as high as 98.3% broadly across Asia (Parikha et al. 2012). Hot-floor VTEP compliance in this study therefore represents a distinct outlier, falling below the national IQR of 89-100% (Hewson et al. 2011). This may infer that compliance is impacted for other protocol driven care such as FASTHUG which incorporates a clinical care bundle for feeding, analgesia, sedation, thromboembolic prophylaxis, health of bed elevation, ulcer prevention and glucose control (Masson et al. 2013). The aim is to embed best practice protocols for routine care during each patient encounter (Borgert, Goossens & Dongelmans 2015). Further research into compliance with bundles is warranted as standardisation is being increasingly challenged (Girbes & Marik 2017) and personalised critical care is emerging in the literature (Vincent 2016).

Standardisation of practice, combined with effective workplace education and support enhances protocol compliance, promotes organisational reliability (Sutcliffe, Paine & Pronovost 2017). The highly standardised evidence based protocolled practice environment is complemented by expert clinical judgement to respond to patient variation. This model of dynamic clinical management relies on vigilance and adjustment of care according to the patient's condition, offering protection against adverse events and unexpected deterioration (Girbes & Marik 2017). The resulting clinical agility recognises the complexity of critical care and fulfils a fifth principle of high reliability, a *reluctance to simplify* process and practice. Positive patient outcomes and high hot-floor activity indicated the presence of this organisational quality, despite high workload being implicated as a barrier to protocol compliance (Daud-Gallotti et al. 2012) increasing clinical risk.

6.3 Maintaining a healthy ICU work environment

A healthy work environment is imperative to ensure patient safety and ideal outcomes, and for the promotion of staff retention and recruitment (AACN 2016). Six essential standards, defined by the American Association of Critical Care Nurses (2016), for establishing and sustaining a healthy work environments in intensive care, are directly applicable to the Australian context. Stipulated requirements include skilled communication and true collaboration to underpin effective decision making, appropriate staffing that achieves suitable matching of patient dependency and nurse skillmix, meaningful recognition of contribution to organisational goals, and authentic leadership (Parker 2016). Magnet hospital attributes are closely aligned (Kelly, McHugh & Aiken 2012), and their relevance to the ICU work environment has been confirmed internationally (Einav, O'Connor & Chavez 2016; Purdy et al. 2010; Stalpers et al. 2017).

Developing an understanding of how the hot-floor model might influence factors associated with the health of the work environment and the subsequent impact on nurse outcomes aimed to address research question five. This study found both positive and negative associations with nurse outcomes in the hot-floor. Areas of potential risk, related to the imbalance between organisational efficiency and effectiveness were identified, which if not addressed, may degrade the work environment and undermine workforce sustainability of the hot-floor model (AACN 2016; Coetzee et al. 2013).

Nursing leadership, a strong mediator for a positive work environment, was weaker and less effective than in the conventional ICU. Diminished visibility of front-line nurse managers in the hot-floor, due to their work being shared between multiple units to cover a larger cohort of beds and staff, was identified as the main factor that negatively influenced the work environment. Core attributes of effective leadership including visibility in the workplace, accessibility, consultation, recognition and support are associated with a positive practice environment and promote optimum nurse outcomes (Brewer et al. 2016; Roche, Laschinger, et al. 2015; Ulrich et al. 2014a).

Effective leadership that promotes staff training, competence and autonomy (Carrothers et al. 2013), controls workload and fosters teamwork to reduce depersonalisation (Lee et al. 2016), and promotes personal accomplishment through supervision and support (Parker 2016), is key to a positive practice environment (Ulrich et al. 2014b). Ineffective leadership due to inadequate resourcing exacerbates the impact on workload due to high frequency of complex clinical interventions at the point of care, greater patient turnover and increased responsibility for junior colleagues. A workload threshold may be reached where conditions impact on nurses' clinical practice such as compliance with protocol driven routine care (Kodadek & Haut 2016; Weissman et al. 2015).

Less effective leadership, insufficient clinical support and the subsequent reduction in personal accomplishment devalues the worth nurses place on their contribution to patient care, undermining their empowerment and further decreasing their motivation to comply with routine care protocols (Purdy et al. 2010). Moreover, practice compliance is associated with adequate leadership, supervision and support (Gifford et al. 2013; Richardson & Tjoelker 2012). This scenario has been implicated in drug related adverse events (Seynaeve et al. 2011), underscoring the need to consider multiple workload factors to promote compliance (Lee et al. 2016; Zarei et al. 2016).

The impact of these factors on the health of the work environment is detrimental to nurse satisfaction and may increase burnout (Klopper et al. 2012). The link between effective leadership and reduced burnout has been recognised in critical care (Moneke & Umeh 2013; Moss et al. 2016b). Front-line clinical nurse leaders provide supervision and support that acts as a buffer for burnout (Weigl et al. 2016), in turn contributing to positive patient outcomes (dos Santos Alves, da Silva & de Brito Guirardello 2016; Ulrich et al. 2014b). Participants from the hot-floor exhibited a pattern of increased depersonalisation and emotional exhaustion coupled with lower personal accomplishment (see Table 5.11) suggesting an increased propensity for burnout. The prevalence of burnout and the threat to health care quality is recognised in a collaborative statement from critical care societies globally (Moss et al. 2016b) which makes a call for urgent action to address burnout. Workload is explicitly implicated in the statement for both nurses (Van Bogaert, Olaf, et al. 2013) and medical staff (Tironi et al. 2016). Effective leadership moderates workload to balance efficiency and effectiveness of the organisation to promote clinician wellbeing (Lyndon 2016).

Strong clinical leadership and effective clinical supervision also promote nurses' sense of personal accomplishment (Stanley 2014) and where lacking exacerbates intention to leave (Roche, Duffield, et al. 2015; Tourangeau, Cranley, et al. 2010). Low personal accomplishment and perceived clinical competency are linked to nurse burnout (Van Bogaert et al. 2017), compounded in the hot-floor work environment by reduced clinical supervision for nurses providing complex care to critically ill patients (Welp, Meier & Manser 2016). Clinical bedside nurses provided more frequent mentorship (6%) and clinical advice (5%) to colleagues while also being responsible for the clinical management of their own allocated patient. While this is an accepted professional practice in ICU, if consistently expected then the risk of workload fatigue may be exacerbated (Steege & Rainbow 2017). A consequence of this identified in an earlier study found reduced access to formal education and support structures diminished personal accomplishment and increased emotional exhaustion (Dawson et al. 2014). Without appropriate resourcing to provide adequate supervision and mentorship then clinical training and professional development are less likely, the practice environment deteriorates, the risk of burnout is exacerbated and quality of care may suffer (Haerkens et al. 2015; Ulrich et al. 2014a).

Effective leadership also promotes a culture of safe patient care by fostering open communication, teamwork and staff empowerment (Squires et al. 2010). This represents the fifth principle of high reliability organisations, *deference to expertise* (Padgett et al. 2017), where the bedside nurse is recognised as the knowledge source regarding their patient's current condition (Chassin & Loeb 2013). A HRO recognises that front-line staff ideally placed for early detection of emerging problems and empower them to participate in operational and clinical management planning, and to make decisions (Singer et al. 2013). Effective front-line leadership is the key-enabling factor for achieving staff autonomy and thereby reduce the risk of clinical deterioration and missed care (Padgett et al. 2017). Due to front-line management and education resource constraints, the hot-floor failed to fully meet this requirement with bedside clinical nurses receiving less support for autonomous practice within the multidisciplinary ICU team.

While hot-floor nurses considered nurse leadership to be less effective, nurses from both units rated their respective practice environments in broadly positive terms. Though not statistically significant, hot-floor nurses consistently rated participation in hospital affairs, presence of nursing foundations for care and adequacy of staffing and resources lower. Participation fosters autonomy and improves nurse retention, two key determinants of effective leadership (Roche, Duffield, et al. 2015). Limited supervision and nurse manager support fail to convey the presence of nursing foundations for delivering care, to promote a nursing philosophy or instil confidence in nurses regarding their clinical competence (Fairchild et al. 2013; Gikopoulou et al. 2014). Inadequate staffing and resourcing again is attributed to insufficient management, education and clinical support resources. Organisational support in the form of access to educational opportunities and career development are strong incentives for the retention of critical care nurses (Goldsworthy 2017).

In addition to practice environment factors, hot-floor nurses also rated multiple work factors lower than their conventional ICU counterparts. Poorer roster flexibility, lower occupational health and safety, and lower perceived quality of care were manifested by reduced job satisfaction, all risks to maintaining a healthy work environment and positive patient outcomes

(AACN 2016). Staff churn exacerbated lower satisfaction with approximately 13% more hot-floor nurses intending to resign within 12-months. This is primarily due to a greater sense of depersonalisation attributed to limited nursing leadership and a lower sense of cohesion (Djukic et al. 2012; Matlakala, Bezuidenhout & Botha 2014a).

Disconnected or isolated nurses experience poor collegial communication and increased emotional fatigue that manifests as an unfeeling, impersonal or callous response toward patients, family and colleagues (Moneke & Umeh 2013; Moss et al. 2016a; Vahey et al. 2004). Up to 48% of critical care nurses have been found to experience depersonalisation from which the subsequent professional and social isolation may hinder participation, undermine teamwork and compound burnout (Li, Ruan & Yuan 2015; Mealer 2016; Samur & Intepeler 2016). The presence of a nurse manager who is visible and communicates effectively, strengthens the organisational structure and protects the work environment and can reduce the risks associated with burnout (Regan, Laschinger & Wong 2016; Van Bogaert et al. 2017).

In contrast to the disadvantages described by nurses in regard to the hot-floor work environment, there was a distinct advantage to working within an integrated service model with a large agile clinical workforce. Agility in this context is the ability of an organisation's workforce to respond rapidly to changes in demand in terms of patient volume and acuity through flexible staffing models including nurse:patient ratios (Patri & Suresh 2017). Greater workforce mobility indicates the flexible operational contingency of the hot-floor effectively responded to fluctuating conditions while maintaining elements of a positive work environment promoting organisational resilience (Riley et al. 2010). Due to internal staffing contingencies nurses were less likely to be redeployed to other wards on a short-term shift-by-shift basis than those in the conventional ICU. Intensive care nurses possess a broad range of skills applicable to complex patients in a majority of clinical specialties, and as such are highly mobile across the hospital (Matlakala 2015). However, redeployment to an unfamiliar clinical setting where immediate care is required by multiple unknown patients, is poorly regarded by ICU nurses and creates considerable anxiety (Matlakala 2015).

Nurses feel greater empowerment when their expertise is appropriately utilised and their clinical competency, performance and involvement in decision making contributes to positive patient outcomes (Choi, Kim & Kim 2014; Van Bogaert et al. 2016). Empowered workplaces provide formal and informal sources of power derived from access to information, support and resources for nurses to accomplish their work effectively and improving the quality of care, (Purdy et al. 2010). Professional autonomy through active participation in determining the clinical care provided serves to increase the perception nurses hold in regard to the meaningfulness of their role (Georgiou, Papathanassoglou & Pavlakis 2015; Gikopoulou et al. 2014; Van Bogaert et al. 2016). Redeployment to unfamiliar work environments precludes multidisciplinary specialist collaboration and diminishes collegial support reducing the opportunity for active participation and the nurse’s sense of practice proficiency (Breau & Rhéaume 2014; Cranley et al. 2012). Nursing staff respond by taking sick leave and changing shifts creating instability within the ICU practice environment to the detriment to nurse and patient outcomes (Duffield et al. 2015). A lower absenteeism rate is viewed as a proxy for a healthy workforce and work environment (Ontario Health 2010). Furthermore, Chen et al. (2007) established that structural factors that destabilise the work environment and diminish empowerment for individuals also impact on teamwork due to participants being less cooperative and more cynical about organisational goals. While education and transformational leadership are key empowerment enablers, cohesive teamwork achieved through nurse-to-nurse support, workload sharing, multidisciplinary communication and collaboration, and exemplary professional practice in a familiar work environment are essential to fulfil Magnet hospital designation requirements (Breau & Rhéaume 2014; Walker, Fitzgerald & Duff 2014).

Where external redeployment was required, participants shared a similar view that deployment to other units should be based on a formal agreement, with appropriate policies and procedures that describe triggers for the return of staff to accommodate unplanned ICU activity (Matlakala 2015). The opportunity to move staff internally between unit pods on a shift-by-shift basis provides an alternative to external redeployment, retaining nurses within a familiar practice setting and enhancing nurse skill-mix matching to patient acuity, positively influencing the work environment and patient outcomes (Aiken, Sloane & Griffiths 2016; Cho et al. 2014; Iapichino et al. 2007). While considered logically feasible from an organisational perspective, hot-floor nurses perceive this strategy as a poor use of their critical care skillset. Patient dependency was more varied allowing nurse:patient ratios to be modified accordingly, improving the utilisation of available staff and further enhancing operational contingency (Nguyen, Wunsch & Angus 2010a). Differing nurse:patient ratios may adversely impact ICU nurse satisfaction but reduced redeployment is likely to represent a more favourable compromise.

However, the positive effect of lower nurse redeployment may have been countered by work environment instability due to the ineffective leadership. Work environment instability can arise from different characteristics of changing front-line nursing managers that, when combined with a large agile clinical workforce and a changing high volume patient casemix, increases unit complexity to a point that may be detrimental to nurse and patient outcomes (Duffield et al. 2015). Whether due to secondment opportunities or dissatisfaction with the role, nurse manager turnover has been implicated in poor patient outcomes (Warshawsky et al. 2013) and adversely affects organisational outcomes (Steege et al. 2017). Increased workload due to instability associated with shift-to-shift staff changes, frequent mentoring of new colleagues or the frequent turnover of nurse leadership positions, in complex practice environments with insufficient clinical support, limited participation and low personal accomplishment, predisposes hot-floor nurses to burnout (Tao et al. 2015). Consequently, staff retention deteriorates, instability is exacerbated and an unhealthy work environment cycle of events is created putting nurses and patients at risk, and undermining organisational reliability (Haerkens et al. 2015; Hendrich & Haydar 2017; Pretorius & Klopper 2011).

Also in this study up to 25% more hot-floor nurses worked a 12-hour shift roster. Evidence on the reasons nurses adopt this rostering pattern is equivocal with studies providing conflicting findings on driving factors such as work balance, organisational imperatives such as cost and continuity of care, and managing work environment related stress (Clendon & Gibbons 2015; Harris, Sims, et al. 2015). Greater access to 12-hour shifts reflects a trend to condense contracted work hours into fewer shifts and increase the number of non-working days (Dall'Ora et al. 2015). While improvements to job satisfaction and nurse retention have been suggested (Stone et al. 2006), more recent studies have indicated nurses experience limited roster flexibility and increased fatigue and burnout (Kunaviktikul et al. 2015; Moreno Arroyo et al. 2013; Pryce 2016).

Risks to nurse welfare due to longer shifts may also be compounded by increased paid overtime (Dall'Ora et al. 2015), worked by 22% more hot-floor nurses. Enhanced operational flexibility that enabled higher patient throughput was also associated with nurses working more paid overtime in a technically complex and emotionally demanding work environment that may compound nurse fatigue (Pastores 2015). Overtime work is a key negative indicator of a healthy workplace because it can be used as a proxy for staffing levels and workloads and is a significant cost for health services (Ontario Health 2010). Longer shifts exacerbate these effects, creating a potentially unsafe practice environment with a greater risk and adverse event being experienced by nurses and patients (Griffiths et al. 2014; Liu, Lee, et al. 2012; Lobo et al. 2017).

Maintaining a healthy work environment in the hot-floor therefore poses a significant management challenge in the context of sustained high workloads and risk of fatigue. Organisational factors have a significant impact on the psychological wellbeing of nurses in ICU (Galletta et al. 2016; Weled et al. 2015). Consistently lower ratings reported for practice environment attributes and contextual work factors, combined with a greater predisposition to burnout suggest that organisational management strategies and resourcing of leadership and clinical support roles need to be better aligned to requirements for a healthy work environment. Burnout exacerbates this relationship (Chuang et al. 2016; Fonseca & Mello 2015) and if not proactively managed may result in the ICU hot-floor organisational model, from a nurse workforce perspective, not being sustainable in the long term (AACN 2016; Moss et al. 2016b).

The link between nurses' work environment and patient outcomes has been confirmed repeatedly by robust empirical research in acute care settings (Duffield et al. 2015; Olds et al. 2017; Xiao et al. 2017). However, in this study, hot-floor patient outcomes were not affected despite the high-risk work environment for nurses. The fact that the hot-floor nurses work environment did not translate into poor patient outcomes points to the mitigating influence of the highly standardised structural, process and practice work environment typical of ICUs internationally and is a core requirement for high organisational reliability (Bennett 2015; Scales & Rubenfeld 2016).

6.4 Protecting high risk patients through standardisation

Organisations with high reliability recognise the value of standardising structures for evidenced based service delivery and operational processes that optimise workflow and workforce practice to reduce variation and mitigate risk (Hines et al. 2008; Vogus & Iacobucci 2016). As previously reported, despite the high-risk hot-floor work environment, patient outcomes including crude and standardised mortality, unplanned extubation, CLABSI or pressure injuries were not adversely affected. Outcomes for the hot-floor compared favourably with other countries including lower crude mortality than in the UK (10.2% vs. 14.6%) (ICNARC 2015), unplanned extubation within the lowest quartile compared to rates internationally (3.2% vs. 0.5 - 14.2%) (Selvan et al. 2014), equivalent CLABSI rates to those in the US (1%) (Pronovost et al. 2016), and a lower prevalence of pressure injury than rates reported internationally (16.2% vs. 18-30%) (Coyer et al. 2015; He et al. 2016). These findings refute the large body of evidence in the international literature reporting that high ICU occupancy is detrimental to patient outcomes (Eriksson et al. 2017; Fernandez 2015; Reddy et al. 2015). Recent studies have also identified that pooling of dedicated specialty ICUs into mixed integrated critical care services improves efficiency while ensuring effective patient outcomes (van der Sluijs et al. 2017).

Mitigating the effects of high occupancy and workload is visible front-line management (Clay-Williams et al. 2014) that encourages frequent interaction with clinical staff to promote compliance with standardised best practice (Dirik & Seren 2017; Weng, Kim & Wu 2017). The uptake of standardised protocols including care bundles and order sets to reduce risk and facilitate measurable processes and outcome improvements is promoted as best practice internationally (Soares, Bozza, et al. 2015; Weled et al. 2015). This is a core requirement for organisational resilience and is being addressed through increasing emphasis on ICU structures and processes to overcome barriers to compliance (Balas et al. 2013). Reducing harmful variation in routine clinical care promotes optimal patient outcomes and contributes to high reliability in ICU (Nguyen, Wunsch & Angus 2010b; Sutcliffe, Paine & Pronovost 2017). Both units in this study reflected highly standardised work environments across multiple processes and practices indicating that the fundamental HRO principle of *preoccupation with failure* was an organisational goal. However, the hot-floor did not fully achieve this principle as efficiency outweighed effectiveness in terms of clinical risk. In particular, resourcing for effective leadership, supervision and support was inadequate. Furthermore, greater *sensitivity to operations* is required to proactively manage workload to enhance compliance (Lee et al. 2016) and anticipate risks to organisational outcomes for staff and patients (Padgett et al. 2017). The hot-floor model only partially fulfilled this requirement.

While high reliability organisations value standardisation there is a *reluctance to simplify* process and practice to a point where judgement, collaboration and autonomous communication are stifled (Padgett et al. 2017). This is in recognition of the complexity inherent in the intersection of organisational factors, operational processes and clinical expertise that occurs to optimise outcomes. The increased clinical risk evident in the hot-floor model did not translate to poor patient outcomes suggesting that a *reluctance to simplify* was present, and the ICU team remained vigilant and responsive to the patient's condition.

The combination of standardised practice supported by individualised patient care is promoted by Vincent (2016) who argues that simple protocols do not work for complex patients as over-standardisation leads to clinician desensitisation. Complacency may result from the constant of protocol-guided care without the challenge of clinical assessment, analysis, adjustment and reassessment of the patient's condition. This model of care that embraces agility, investigation and clinical judgement, and is supported by best practice protocols with simple checklists, applied at the discretion of the ICU team, to customise care for optimal outcomes (Scheithauer et al. 2017). Clinicians relying on protocols and checklists need to continually assess whether the benefits are being realised or detect potential harm to ensure patients are afforded protection (Kavanagh & Nurok 2016). Appreciating that standardised care can be inappropriate for some patients will enhance the understanding of how to improve compliance with standardised care when indicated to optimise patient outcomes.

6.5 Human resourcing for high organisational reliability

Workforce structures in this study were similar and representative of ICUs nationally. However, resourcing differed in relation to the full staffing complement with the hot-floor having less nursing management (11.0% vs. 16.0%) and educator positions (1.25% vs. 3.70%) than the conventional ICU. A higher proportion of RNs in years one to two (36.2% vs. 19.4%) and fewer nurses with an ICU qualification (43% vs. 49%) may have compounded the effect of inadequate clinical supervision and support (Van Bogaert, Kowalski, et al. 2013) manifested by hot-floor nurses reporting lower personal accomplishment.

Organisational reliability requires workforce preparedness and appropriate resourcing (Aboumatar et al. 2017) that extends beyond clinical staffing for optimal patient care (Cho et al. 2014) to encompass management, education and front-line support roles (Bennett 2015). Intensive care workforce research has primarily focused on conventional ICU bedside nurse:patient ratios with opinion-based recommendations for other front-line roles, though nothing specific to the hot floor. Matlakala et al. (2014a) identified the resourcing challenges in large ICUs due to unit structure, layout and size but concluded no effective strategies currently existed. More recently Webb et al. (2016) described the emergence of the 'mega' ICU hot-floor model in Australia, the inherent staffing challenges and the importance of strong nursing leadership, though no evidence based resourcing recommendations were proposed.

The Australian College of Critical Care Nurses recently released ten workforce standards ('the standards') (ACCCN 2016) developed through systematic review, critical appraisal and evidence grading (NHMRC 2014). These provided a robust framework for considering hot-floor workforce resource requirements. Standard one recognises that a one size fits all model is not appropriate for contemporary ICUs. Patient casemix, unit layout and size are considerations for resourcing direct patient care and other front-line roles, a foundation principle underpinning the standards. The hot-floor upheld this staffing principle for nurses providing direct clinical care (Standard two) with nurse:patient ratios determined by acuity and dependency, and by ensuring specialist qualified nurses (Standard three) were available. However, a broader range of nurse:patient ratios was applied using an incremental approach to determining nursing requirements thus moving away from the traditional one nurse to one patient staffing model through to one nurse to four patients (ACI 2015). Though an unpopular strategy among ICU nurses, this staffing approach contributes to timely patient access during periods of high demand, high occupancy and where hospital organisational constraints delay patient transfers to wards. Nurse redeployment may also be reduced through the greater options for internal staff redistribution as found in this study.

Traditionally, nurse allocation has been determined by clinical assessment of a patient's needs with limited objective criteria used to support staffing decisions other than the patient being intubated with mechanical ventilation. An objective model is therefore required to determine staffing requirements to better match resources and skillmix, optimise throughput and provide a clear rationale for staff allocations. The Therapeutic Intervention Scoring System (TISS) (Cullen et al. 1974) is one method but uptake for unit-based staffing decisions in Australia has been found to be only 18% (Rischbieth 2006) which was attributed to the burden for nurses to complete TISS for each patient. An alternative is the Nursing Activities Score (NAS) that has been validated in ICUs across 15 countries (Miranda et al. 2003) and accounts for 81% of nursing time, compared to 43% by TISS (Miranda et al. 2003). Though adopted in Europe and Brazil (Padilha et al. 2010) NAS has not been implemented in Australian ICUs highlighting the need for further research on this topic as described later in this chapter.

The fourth workforce standard stipulates that nursing management be provided by a specialist critical care nurse dedicated to the service nurse manage role and involved in decision making at all levels within the administration. While evident in the hot-floor, the level of resourcing was inadequate, highlighting the need to consider a broader array of management roles incorporated into a management model aligned to pods of beds, no larger than 10 beds, to support effective management and authentic leadership. The hot-floor nurse manager role was shared across 54 beds over four separate units comprised of approximately 280 FTE nursing positions with a larger actual head count. Afterhours this role was provided by a clinical manager for the service as a whole, limiting availability to direct care staff needs. This role provides a bird's eye view of the service as a whole promoting situational awareness, a core requirement for operational contingency and organisational resilience. Efficiency and effectiveness of the hot-floor model is contingent on a whole of service operational coordination and resourcing across all pods to accommodate the changing organisational environment.

To support this the clinical manager role, unit based support and leadership positions need to be incrementally aligned to the size of the nursing workforce by modeling the ratio of these resources per each pod of ten to 12 beds (BACCN 2013; CICM 2011). This approach is also applicable to nursing education, clinical and ancillary staff support resources so as to adequately address ACCCN workforce standards five, six, seven and ten respectively. However, in recognition of fiscal and workforce constraints, and the need to avoid a top-heavy management model, alternative strategies need to be considered.

The 'ACCESS' nurse role, ACCCN workforce standard six, provides **A**ssistance, **C**oordination of patient activity, **C**ontingency for unplanned demand, **E**ducation for clinical staff, **S**upervision and **S**upport for the provision of direct patient care (ACCCN 2016). The role, staffed by senior clinical nurses, aims to augment front-line manager and education roles, facilitates workforce agility, enhances quality of care and safety, and offers a new clinical career pathway. Mechanisms for greater participation in hospital affairs are made available, autonomy is promoted through personal accomplishment and risk of burnout reduced. Senior clinical nurses are a precious resource for all aspects of organisational, operational and quality management activities in ICU, and their retention promotes a healthy work environment that benefits both nurse and patient outcomes. The ACCESS nurse role had been adopted by the hot-floor but resourcing according to the size of service and its workforce was inadequate, undermining the effectiveness of the position. The conventional ICU provided a similar role, along with a front-line manager and additional education resources, all of which were dedicated to a single discreet unit. Taking into account the need for an incremental approach and the ACCESS nurse role, a workforce resource model for front-line nursing management, education and clinical support role, is proposed in section 6.7.

Similar to front-line nursing roles in the hot-floor, lower resourcing was also provided for medical, allied and ancillary positions. Total hot-floor medical staffing per bed (1.1 FTE) was well below the conventional ICU (2.3 FTE) and below the national average (1.5 FTE). Dedicated ICU pharmacist resourcing was also lower for the hot-floor (0.35 vs. 1.0 FTE) as was ancillary support positions (1.35 vs. 3.0 FTE). Adequate resourcing of these positions is inextricably linked to quality of care and optimising patient outcomes. For Intensivists this level of resourcing is well below recommended staffing recommendations (CICM 2011) and linked to burnout due to high workload and emotional stress (Meynaar et al. 2015).

As pointed out by Seppelt (2013) in regard to the state of ICU in Australia, the mega ICU has many staffing implications, not only related to physical size but also a new work place dynamic. In a large hot-floor service the intensivist workforce may become two tiered, with a small core of permanent staff guiding clinical care and supporting management activities, while the remainder focus only on patient care with no other organisational interaction. This raises concerns about fragmentation of care and lower commitment to the organisation due to a 'shift-work' mentality. An incremental approach to medical and ancillary staffing is also required to better align staffing requirements.

6.6 Strengths and limitations

The findings of this study need to be interpreted in the context of methodological strengths and limitations to elicit meaningful implications for health policy, planning and practice that pertain to ICU organisation and management. A key limitation in regard to retrospective cross-sectional cohort studies the lack of control for confounding and bias in the study population highlighting the need for appropriate risk adjustment and controls where possible. Critically ill patient populations have a high degree of heterogeneity due to the broad range of demographic characteristics, illnesses, injuries and multiple comorbidities. Sample variation was controlled by drawing from the explicit adult patient population from ICUs with analogous case-mix, level and type of intensive care service provision and clinical workforce structures (Burmeister & Aitken 2012). Samples were statistically matched on multiple casemix and clinical criteria and were representative of the national tertiary adult ICU patient population.

Any association between organisational factors and patient outcomes, particularly in relation to volume and mortality, remains tenuous, with any direct causal relationship confounded by heterogeneous patient populations (Dodek 2014; Kuiper & Girbes 2015). Randomised patient selection was employed to minimise potential confounding although the controls implemented do not guarantee complete eradication of confounding variables. Notwithstanding this limitation, the value of organisationally mediated outcome research in ICU is being increasingly recognised (Parry & Power 2015; Sakr et al. 2015).

The quality of the extracted sample data was high with minimal missing data due to the sites' clinical information systems. Sample sizes were comparable to similar studies into ICU organisational factors and outcomes. The small effect size found in significant and non-significant test results demonstrates the need for a larger sample size to ensure adequate statistical power and avoid Type II errors.

As noted earlier, national tertiary adult ICU patient population data are skewed because of outliers and heterogeneity; this was also evident in the samples studied here. While data transformation was attempted to explore if parametric tests could be used, no improvement in distributions was identified. Non-parametric tests were therefore adopted reducing statistical power and potentially contributing to Type I and Type II errors in the analysis.

Given the heterogeneity of the ICU patient population generalisation of findings to other levels or organisational types of adult ICUs is limited. However, the study sites and workforce profiles were well matched providing a solid evidence based foundation for future national multi-centre studies into ICU organisation.

The use of a cross-sectional survey to explore the association between nurse outcomes and organisational factors limited the ability to control for confounders in the study population. Prospective purposive sampling enabled clinical ICU bedside nurses to be included. The resulting sample size may have increased the risk of bias, underpowered the analysis and the risk of a

Type II error. The sample size was however based upon previously published similar studies and considered feasible for the scope of this research. Workforce structures and staffing models were matched and stable across both sites, with equivalence of the ICU nurse samples demonstrated. The samples were also closely aligned with characteristics of the national tertiary ICU nurse workforce.

The two data collection periods may influence any causal inference made regarding the association between patient outcomes, the practice environment and nurse outcomes. To account for possible variation due to separate collection periods it was established that the service profile of each study site, patient casemix and clinical workforce remained constant over the full duration of the research.

Selection of the survey instruments was based upon an evidence-based approach. Identification of statistically significant relevant nurse outcomes provided a core dataset that then enabled selection of the most appropriate survey instruments. Pilot testing provided validation of the instrument and valuable feedback on the survey design. Both the PES-NWI and MBI have had extensive psychometric validation in nursing populations and this was subsequently confirmed in the current study.

Using both hard copy and electronic survey formats could potentially impact on completion rates, missing data and ultimately results. Both methods were used to suit the sample population and their workplace to optimise access to the survey and facilitate collection. Controls were put in place to maximise completion rates including an instrument pilot to optimise the survey design in both hard and electronic formats, instruction was provided on completion during the information sessions and the electronic format settings precluded moving forward if there was missing field. Despite the long survey format the response rate and survey completion rate were high with minimal missing data. This may be attributable to the strong local support expressed by ICU nursing staff for the study, survey administration supported by the local nursing management and education staff, and high visibility of the investigator.

6.7 Implications for practice, policy and management

The Australasian Health Facility Guidelines promote the hot-floor as an organisational solution to growing demand for intensive care. This policy driven planning approach is based on a number of assumed efficiency and effectiveness benefits. This research has demonstrated for the first time that the hot-floor model more efficiently manages patient throughput. This was achieved by improved service integration across multiple subspecialties enhancing operational flexibility and organisational resilience. However, this research identified an inherent risk to patient and nurse outcomes associated with the intensified level of activity and under resourcing of key front-line management, education and support positions. These implications need to be addressed through workforce policy, planning and management strategies specific to the hot-floor work environment.

Two key organisational characteristics of the hot-floor require a policy framework that can guide proactive workforce planning and the development of a mechanism to effectively manage patient volume and occupancy. In regard to workforce policy and planning, the overall service level manager coordination role is pivotal to optimising operational flexibility, patient throughput and organisational efficiency. During business hours each individual pod has a dedicated nursing manager and educator with an overarching nursing manager to coordinate the hot-floor service. In contrast during after-hours, which constitutes a majority of the working week, only the overall hot-floor service manager is resourced limiting the effectiveness of this role in terms of supporting and supervising clinical staff.

The ICU stands ready 24-hours a day, 365 days a year, for unplanned patient admissions and those suffering critical deterioration. A clinical leadership model is required that can respond appropriately to support clinical staff during peak activity. This study does not advocate multiple management positions on a 24-hour basis. A viable alternative in the Australian context, which acknowledges the hot-floor model, is provided by the workforce standards for ICU nursing by ACCCN (2016) which recommend adoption of the newly evolving ACCESS nurse role, as described in Section 6.5 of this discussion. In summary the role provides **A**ssistance, **C**oordination of patient activity, **C**ontingency for unplanned demand, **E**ducation for clinical staff, **S**upervision and **S**upport for the provision of direct patient care.

The ACCESS role aims to supplement the support provided by nursing managers, educators and other clinical support positions. According to the ACCCN standards for the resourcing of ACCESS nurses, a key determining factor is the proportion of ICU qualified staff on a shift that can be used to guide ACCESS nurse ratios per number of nurses and beds. The ACCESS nurse can support staff during high workload and improve compliance with evidenced based care through enhanced supervision and mentorship. Potential patient benefits include rapid access to definitive care due to the readily available contingency afforded by the ACCESS nurse role.

Though ACCCN is recognised as the peak professional ICU nursing body in Australia, currently there is no policy framework to embed ACCCN workforce recommendations into workforce planning and management. This study proposes a minimum workforce staffing model for the hot-floor for front-line management, education and clinical support roles, according the ACCCN standards (see Table 6.1.). These roles have been demonstrated to mitigate nurse dissatisfaction and burnout, and are recognised as core requirements for a healthy work environment in ICU that promotes positive patient outcomes. The proposed staffing ratios in Table 6.1 are modelled on a pod of 12 ICU beds that would be nested within a hot-floor service.

The scenario maintains the whole of service nursing manager role on a 24-hours basis and creates ACCESS nurse opportunities in clinical coordination, rapid response and outreach services, clinical education and support roles. The ACCESS nurse role facilitates a clinical pathway for senior ICU nurses to increase their scope of practice while establishing a succession plan for senior management and education position. Rotation into these roles for a consolidated period provides career opportunities and promotes personal accomplishment. The ACCESS role could strengthen the influence of the nursing manager with clinical bedside staff through mentoring, conveying the goals of the organisation and providing real time support and visible supervision. The associated costs associated with this staffing recommendation will always be brought into question but these should be considered in regard to the hidden costs of staff turnover, overtime and other operational support costs already incurred. The model would also optimise operational contingency, a key benefit of the hot-floor model, to manage the demand for intensive care. Clinical staff whose workload is controlled and well supported promotes organisational resilience and reliability.

The roles and resourcing proposed in Table 6.1 would contribute to the organisational resilience of the hot-floor model.

Table 6.1 Proposed nursing management, education and clinical support workforce model for a single ICU pod within a four pod hot-floor

Organisation Level	Role[1, 2]	Time[3]	FTE[4] Allocation	Comment
Hot-floor Service	Nurse Manager	BH	1.0 (0.25 pod[5])	Senior leadership for quality, human resources, budget and service level operational coordination
		AH	1.0 (0.25 pod)	Service level operational coordination
	Clinical Nurse[6] Consultant	BH	1.0 (0.25 pod)	Clinical practice, education and quality
	Clinical Nurse Consultant	BH	1.0 (0.25 pod)	Research and quality
	Clinical Nurse Consultant	BH	1.0 (0.25 pod)	Equipment and resources ACCESS nurse role (1 year rotation)
	Nurse Liaison /Outreach	BH	2.0 (0.5 pod)	Rapid Response Team member, clinical support role for ward based close observation beds ACCESS nurse role (1 year rotation),
		AH	2.0 (0.5 pod)	
Unit/Pod[5]	Nurse Unit Manager	BH	1.0	Operational coordination of unit level activity and resources, quality management and rostering
	Clinical Nurse Educator	BH	1.0	ACCESS nurse role (1 year rotation)
	Clinical Coordinator	AH	1.0	Supernumerary ACCESS nurse role (Allocated per shift)
	Clinical Support	BH	2.0 (1 per 6 beds)	ACCESS nurse role (Allocated per shift) Based on 50-75% of staff with ICU qualifications
		AH	2.0 (1 per 6 beds)	

Notes:

1. Front-line management, education and support roles only
2. Staffing allocation for nurses providing direct care requires nursing ratios based on a multifactor dependency model that considers number of organs simultaneously supported by physiological therapies, risk of an adverse event (taking into account invasive ventilation), planned interventions and routine care requirements scored using a validated tool.
3. Seven days a week based on business hours (BH) and afterhours (AH) including weekends
4. FTE allocation PER SHIFT based upon a four pod hot-floor model
5. Pod size based upon 12 beds
6. Clinical Nurse Consultants in Australia are defined as advanced practice nurses that work with the clinical speciality management teams to provide professional leadership on quality improvement, education and clinical research (Gardner et al. 2017)

The hot-floor work environment was characterised by high activity, complexity and occupancy with staff receiving less support than the conventional ICU. The enhanced operational flexibility of the model resulted in higher unit occupancy and the hot-floor consistently operating at full census, and well above recommended occupancy rates in the literature for conventional ICUs. Though the model was more efficient and did not compromise patient outcomes, the risk of an adverse event was higher. Furthermore, the impact on staff highlights the need for more clinical, education and managerial support for bedside ICU nurses. This should be coupled with proactive management of occupancy though optimal levels for the hot-floor model are not known, requiring future research to be undertaken to inform organisational policy. Once determined, a mechanism to control occupancy levels across the hot-floor service as a whole embedded in policy and health services management, would contribute to an improved work environment and the welfare of staff and patients. Workforce planning, specific to the size, configuration and workload of the hot-floor model, along with determining and managing unit occupancy for a healthy work environment, are the most immediate priorities. While the nursing workforce was a primary focus in this study, similar workforce and work environment considerations are required for medical, allied and ancillary staff.

This first study of the hot-floor model provides an insight into areas for future research to inform the effective management large intensive care services. Addressing the deficit of evidence-based policy, planning and management guidelines is necessary for the hot-floor model to realise the assumed organisational benefits and be a solution for the delivery of critical care services into the future.

6.8 Future research

Next steps in understanding the effect of the hot-floor model on patient and nurse outcomes includes the need to validate the findings by replicating this study in a larger number of units to continue to examine the efficiency and effectiveness of the flexible service model in large ICUs. A national longitudinal prospective study of patient outcomes, further refined by considering contemporary evidence to expand the suite of outcome measures such as VAP rates, would provide greater opportunity to control for heterogeneity to better understand any causal effects of the hot-floors organisational characteristics. Similarly, the instrumentation identified in this study for surveying intensive care nurses could be applied in a national study to achieve a much larger sample for analysis and to provide stronger psychometric validation. Australian intensive care services are well placed to undertake this research due to ICU service levels being well defined and ubiquitous. Furthermore, ANZICS and ACCCN provide strong professional leadership nationally and have established high quality data registries to enable comprehensive data collections on a broad range of organisational, operational, clinical, workforce and quality aspects of the ICU.

This study suggested a volume threshold may exist where the benefits of high activity are lost and the work environment is adversely affected, impacting staff welfare and clinical quality. In this case this impact was manifested by reduced staff compliance with protocol driven care compromised by workload. Future research on the associations between high volume, high occupancy and outcomes in the cohort of complex critically ill patients with high severity of illness would better target the volume-outcome phenomenon and understand the influence of unit occupancy. Furthermore, understanding what an optimal level of occupancy looks like in the hot-floor model is needed to inform future operational policy and planning.

The hybrid triage process of the hot-floor model, with a mixture of closed and open beds, may be a contributing factor to its high volume and occupancy. Future international studies to compare the triage mechanisms for ICU in various health settings may unearth valuable lessons for improving access while controlling volume and occupancy that could benefit units across the spectrum from closed to completely open models. Given the differences in ICU nurse:patient ratios between models and healthcare settings internationally, for example a 1 nurse to 1 ICU patient ratio in Australia, further investigation of clinical staffing models should build on existing evidence but in the context of the hot-floor in regard to patient throughput, quality and outcomes.

Quality of care in ICU has been inextricably linked to standardisation of evidence-based practice. This study indicated that it did afford a degree of protection against adverse effects in the high-risk environment of the hot-floor but compliance was a key determinant for maximum effectiveness. Multi-centre studies that explore how work environment conditions specifically in ICU affect staff compliance could make a major contribution to quality of care and patient safety. Importantly, investigating how to better balance personalised vs. protocolled critical care would inform the current professional debate on how far standardisation should permeate through clinical practice to optimise patient and staff outcomes.

A core characteristic of ICU is the high workforce resource requirement to support the model of care. In the conventional ICU workforce requirements including nurse:patient ratios and front-line management, education and support roles are clearly defined. This is not the case for the hot-floor and as such provides new opportunities for future prospective observational and interventional staffing research. The hot-floor reflects the contemporary views on patient dependency where the level of intensive care required is on a continuum of complexity and acuity, rather than being classified as either an ICU or HDU patient with nurse:patient ratios of 1:1 and 1:2 respectively. As such a greater range of dependencies and nurse:patient ratios are being considered. Patient stratification is determined by clinical status but to date in Australia the uptake and evaluation of dependency tools such as TISS has been limited. Future research into the barriers to adoption and potential alternatives would provide hot-floor managers guidance on appropriate staff allocation that is effective, efficient and more readily justifiable to hospital administrators. Development and testing of a model based on a combination of factors including the level of physiological support provided, risk of clinical deterioration, nursing care requirements and planned interventions could provide a quantifiable guide to staffing across a range of critical care and acute care specialities. Leveraging the lessons of earlier research on the burden of completion and the proliferation of clinical information and administrative systems in ICU would be critical for meaningful evaluation application and impact in the work environment.

Beyond the bedside, this research identified that front-line management, education and support positions were significantly under resourced in the hot-floor. Like bedside staffing, resourcing of these roles is clearly defined for the different service levels of the conventional ICU at different service levels but absent for the hot-floor. This research identified that the hot-floor integrated service model requires different resourcing considerations for these roles not only to provide adequate support to clinical staff but also to a whole of service perspective to maximise operational contingencies. Furthermore, future research into the association between various management and communication styles, and the practice environment in ICU, would provide valuable insight into factors, that are known to influence workforce satisfaction in other acute care environments. This would provide a strong foundation on which to base further research on a staffing model that achieves the potential benefits of the hot-floor while maintaining a healthy work environment for nurses and patients.

Another area of future workforce research would be to undertake interventional studies involving the proposed ACCESS nurse role in ICU. The lack of clinical support in the hot-floor due to the resourcing of front-line management and education resources could potentially be ameliorated by trialling the ACCESS role in accordance with the ACCCN staffing guidelines that take into consideration the proportion of ICU qualified staff on a shift. Furthermore, the role may offer a new clinical career path for senior ICU nurses to better retain them in the ICU, by creating a role with increased scope of practice and autonomy to supplementing formal education and management roles. As the role of the ICU continues to evolve with greater outreach and clinical support services the ACCESS nurse could play a pivotal role by providing immediate operational contingency, enhancing supervision of clinical practice and promoting clinical quality, while positively influencing staff retention. However, these assumptions are not tested. Longitudinal evaluation of the impact of this role has on the work environment and staff turnover, outcomes and associated costs may provide the impetus for its formal adoption in workforce policy and planning.

Ultimately the hot-floor model strives to optimise patient outcomes by ensuring appropriate and timely access to definitive critical care in an environment of increasing demand. Future prospective multicentre research is required to validate the efficiency gains identified in this study. More importantly investigating what organisational inputs are required to optimise the model in terms of both efficiency and effectiveness is essential to achieve sustainable high reliability.

6.9 Conclusion

Improved demand management achieved through greater operational flexibility is a key driver for the adoption of the hot-floor model. The model can however only be sustained in the long term if a healthy work environment is maintained and the underlying risk to patient safety and staff welfare mitigated through appropriate resourcing and workload management. Any gains made in organisational efficiency need to be balanced with corresponding improvements in the work environment to optimise the impact on staff, particularly nurse outcomes and retention to reduce turnover.

Reduction of the hot-floor's inherent high level of managed risk through effective operational mitigation strategies is needed if organisational reliability is to be legitimately achieved and sustained. Four of the five HRO principles would be better satisfied by enhancing *preoccupation with failure* by reducing risk, improving *sensitivity to operations* through improved situational awareness of occupancy, promoting *commitment to resilience* through flexible contingency that balances patient volume with workload, and promote a *reluctance to simplify* by ensuring high quality practice is supported by an appropriately skilled and resourced workforce for a safe and healthy work environment (Aiken et al. 2013).

Without these factors being addressed the potential organisational benefits will not be optimised. By aligning the structure, process and outcome factors inherent to hot-floor model, a new way of working can be achieved that promotes operational agility, responsiveness to growing demand and creates organisational resilience.

REFERENCES

AACN 2005, 'American Association of Critical-Care Nurses standards for establishing and sustaining healthy work environments: a journey to excellence', *American Journal of Critical Care* vol. 14, no. 3, pp. 187-97.

AACN 2016, *Standards for Establishing and Sustaining Healthy Work Environments: A Journey to Excellence, 2nd ed.*, American Association of Critical Care Nurses, Aliso Viejo.

Abbenbroek, B., Duffield, C. & Elliott, D. 2014a, 'The intensive care unit volume–mortality relationship, is bigger better? An integrative literature review', *Australian Critical Care*, vol. 27, no. 4, pp. 157-64.

Abbenbroek, B., Duffield, C. & Elliott, D. 2014b, 'Selection of an instrument to evaluate the organizational environment of nurses working in intensive care: an integrative review', *Journal of Hospital Administration*, vol. 3, no. 6, pp. 143-62.

Aboumatar, H., Weaver, S., Rees, D., Rosen, M., Sawyer, M. & Pronovost, P. 2017, 'Towards high-reliability organising in healthcare: a strategy for building organisational capacity', *BMJ Quality & Safety*, vol. 26, no. 8, pp. 663-70.

ACCCN 2016, *Workforce Standards for Intensive Care Nursing*, Australian College of Critical Care Nurses, Melbourne.

ACHS 2009, *Australasian Clinical Indicator Report: 2001 – 2008: Determining the Potential to Improve Quality of Care*, vol. 10, Australian Council of Healthcare Standards, Newcastle, Australia.

ACHS 2013, *Clinical Indicator User Manual: Intensive Care* ACHS Performance and Outcomes Service, Sydney, Australia.

ACHS 2014, *Australasian Clinical Indicator Report 2006–2013*, Australian Council of Health Care Standards, Sydney, Australia.

ACHS 2015, *Australian Council on Healthcare Standards Clinical Indicator User Manual*, Newcastle, Australia.

ACI 2015, *Intensive Care Service Network – Intensive Care Service Model: NSW Level 4 Adult Intensive Care Units*, vol. 1, Agency for Clinical Innovation, Sydney, Australia.

Agamez, M., Arnal, D. & Garcia del Valle, S. 2013, 'Unplanned extubation: a quality marker of intensive care unit: review of 10 years', *European Journal of Anaesthesiology*, vol. 30, pp. 253-4.

AHIA 2014, *Australasian Health Facility Guidelines*, Australasian Health Infrastructure Alliance, Sydney, Australia.

Aidemark, l., Baraldi, S., Funck, K. & Jansson, A. 2010, 'The Importance of Balanced Scorecards in Hospitals', in M. Epstein, J. Manzoni & A. Davila (eds), *Performance Measurement and Management Control: Innovative Concepts and Practices*, Emerald Bedfordshire, pp. 363-85.

AIHW 2013, *Health Workforce Australia: Nurses in focus*, Adelaide.

AIHW 2014, *Nursing and Midwifery workforce*, Australian Institiute Health and Wealthfare, Canberra.

Aiken, L., Cimiotti, J., Sloane, D., Smith, H., Flynn, L. & Neff, D. 2012, 'Effects of nurse staffing and nurse education on patient deaths in hospitals with different nurse work environments', *Journal of Nursing Administration*, vol. 42, no. 10, pp. S10-S6.

Aiken, L., Clarke, P. & Sloane, D. 2002, 'Hospital staffing, organization, and quality of care: cross-national findings', *International Journal for Quality in Health Care*, vol. 14, no. 1, pp. 5-14.

Aiken, L. & Fagin, C. 1997, 'Evaluating the consequences of hospital restructuring', *Medical Care*, vol. 35, no. 10, pp. 1-4.

Aiken, L. & Patrician, P. 2000, 'Measuring organizational traits of hospitals: the revised Nursing Work Index', *Nursing Research*, vol. 49, no. 3, pp. 146-53.

Aiken, L., Sermeus, W., Van den Heede, K., Sloane, D., Busse, R., McKee, M., Bruyneel, L., Rafferty, A., Griffiths, P. & Moreno-Casbas, M. 2012, 'Patient safety, satisfaction, and quality of hospital care: cross sectional surveys of nurses and patients in 12 countries in Europe and the United States', *BMJ*, vol. 344, p. e1717.

Aiken, L., Sloane, D., Bruyneel, L., Van den Heede, K. & Sermeus, W. 2013, 'Nurses' reports of working conditions and hospital quality of care in 12 countries in Europe', *International Journal of Nursing Studies*, vol. 50, no. 2, pp. 143-53.

Aiken, L., Sloane, D., Clarke, S., Poghosyan, L., Cho, E., You, L., Finlayson, M., Kanai-Pak, M. & Aungsuroch, Y. 2011, 'Importance of work environments on hospital outcomes in nine countries', *International Journal for Quality in Health Care*, vol. 23, no. 4, pp. 357-64.

Aiken, L., Sloane, D. & Griffiths, P. 2016, 'Nursing skill mix in European hospitals: cross-sectional study of the association with mortality, patient ratings, and quality of care', *BMJ Quality and Safety*, vol. 26, no. 9, pp. 559-68.

Aitken, L., Burmeister, E., Clayton, S., Dalais, C. & Gardner, G. 2010, 'The impact of nursing rounds on the practice environment and nurse satisfaction in intensive care: pre-test post-test comparative study.', *International Journal of Nursing Studies*, vol. 48, no. 8, pp. 918-25.

Al Tawfiq, J. & Saadeh, B. 2011, 'Improving adherence to venous thromoembolism prophylaxis using multiple interventions', *Annals of Thoracic Medicine*, vol. 6, no. 2, pp. 82-4.

Al Tehewy, M., El Houssinie, M., El Ezz, N., Abdelkhalik, M. & El Damaty, S. 2010, 'Developing severity adjusted quality measures for intensive care units', *International Journal of Health Care Quality Assurance*, vol. 23, no. 3, pp. 277-86.

Ali, N., Hammersley, J., Hoffmann, S., O'Brien, J., Phillips, G., Rashkin, M., Warren, E. & Garland, A. 2011, 'Continuity of care in intensive care units: a cluster-randomized trial of intensivist staffing', *American Journal of Respiratory and Critical Care Medicine*, vol. 184, no. 7, pp. 803-8.

Amaral, A. & Cuthbertson, B. 2016, 'Balancing quality of care and resource utilisation in acute care hospitals', *BMJ Quality & Safety*, vol. 25, no. 11, pp. 824-6.

Anguera Saperas, L., Colodrero Diaz, E., Garcia Grau, N., Mateo Zapata, E., Roca Biosca, A. & Velasco Guillen, M. 2009, 'Education as a key piece in the prevention and good course of pressure ulcers', *Enferm Intensiva*, vol. 20, no. 1, pp. 19-26.

Anthoine, E., Moret, L., Regnault, A., Sébille, V. & Hardouin, J. 2014, 'Sample size used to validate a scale: a review of publications on newly-developed patient reported outcomes measures', *Health and quality of life outcomes*, vol. 12, no. 1, pp. 176-86.

ANZICS CORE 2013a, *Australian Patient Database Data Dictionary for Software Programmers (Version 4)*, ANZICS Centre for Outcome and Resource Evaluation, Melbourne, Australia.

ANZICS CORE 2013b, *Centre for Outcome and Resource Evaluation Annual Report 2011-2012*, Australian and New Zealand Intensive Care Society, Melbourne, Australia.

ANZICS CORE 2014a, *Intensive Care Resources and Activity in Australia and New Zealand - Annual Report 2012-2013*, Australia and New Zealand Intensive Care Society Melbourne, Australia.

ANZICS CORE 2014b, *Intensive Care Resources and Activity in Australia and New Zealand - Annual Report 2013-2014*, Australian and New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation, Melbourne, Australia.

Arabi, Y., Phua, J., Koh, Y., Du, B., Faruq, M., Nishimura, M., Fang, W., Gomersall, C., Al Rahma, H., Tamim, H., Al-Dorzi, H., Al-Hameed, F., Adhikari, N. & Sadat, M. 2016, 'Structure, organization, and delivery of critical care in asian ICUs', *Critical Care Medicine*, vol. 44, no. 10, pp. e940-e8.

Arabi, Y., Schultz, M. & Salluh, J. 2016, 'Intensive care medicine in 2050: global perspectives', *Intensive Care Medicine*, vol. 42, no. 11, pp. 1-5.

Araujo, T., Rieder Mde, M., Kutchak, F. & Franco Filho, J. 2013, 'Readmissions and deaths following ICU discharge: a challenge for intensive care', *Rev Bras Ter Intensiva*, vol. 25, no. 1, pp. 32-8.

Arbour, C., Gélinas, C. & Michaud, C. 2011, 'Impact of the implementation of the Critical-Care Pain Observation Tool (CPOT) on pain management and clinical outcomes in mechanically ventilated trauma intensive care unit patients: a pilot study', *Journal of Trauma Nursing*, vol. 18, no. 1, pp. 52-60.

Armijo-Olivo, S., Stiles, C., Hagen, N., Biondo, P. & Cummings, G. 2012, 'Assessment of study quality for systematic reviews: a comparison of the Cochrane Collaboration Risk of Bias Tool and the Effective Public Health Practice Project Quality Assessment Tool: methodological research', *Journal of Evaluation in Clinical Practice*, vol. 18, no. 1, pp. 12-8.

Armstrong, R. 2014, 'When to use the Bonferroni correction', *Ophthalmic and Physiological Optics*, vol. 34, no. 5, pp. 502-8.

Aslanidis, T. 2015, 'In search of the ideal intensive care unit model', *Edorium Journal of Intensive Care*, vol. 2, no. 1-3.

Azevedo, L., de Souza, I., Zygun, D., Stelfox, H. & Bagshaw, S. 2015, 'Association between nighttime discharge from the Intensive Care Unit and hospital mortality: a multi-center retrospective cohort study', *BioMed Central Health Services Research*, vol. 15, no. 378, pp. 1-9.

BACCN 2013, *Standards for Nurse Staffing in Critical Care* British Association of Critical Care Nurses, United Kingdom.

Bagshaw, S., Opgenorth, D., Potestio, M., Hastings, S., Hepp, S., Gilfoyle, E., McKinlay, D., Boucher, P., Meier, M., Parsons-Leigh, J., Gibney, R., Zygun, D. & Stelfox, H. 2017, 'Healthcare provider perceptions of causes and consequences of ICU capacity strain in a large publicly funded integrated health region: a qualitative study', *Critical Care Medicine*, vol. 45, no. 4, pp. 347–56.

Baharoon, S., Alyafi, W., Tamim, H., Al-Jahdali, H., Alsafi, E., Al-Sayyari, A. & Ahmed, Q. 2014, 'Continuous mandatory onsite consultant intensivists in the ICU: impacts on patient outcomes', *Journal of Patient Safety*, vol. 12, no. 2, pp. 108-13.

Bai, J., Fügener, A., Schoenfelder, J. & Brunner, J. 2016, 'Operations research in intensive care unit management: a literature review', *Health Care Management Science*, vol. 19, pp. 1-29.

Baker, D., Pronovost, P., Morlock, L., Geocadin, R. & Holzmueller, C. 2009, 'Patient flow variability and unplanned readmissions to an intensive care unit ', *Critical Care Medicine*, vol. 37, no. 11, pp. 2882-7.

Balas, M., Burke, W., Gannon, D., Cohen, M., Colburn, L., Bevil, C., Franz, D., Olsen, K., Ely, W. & Vasilevskis, E. 2013, 'Implementing the ABCDE bundle into everyday care: opportunities, challenges and lessons learned for implementing the ICU Pain, Agitation and Delirium (PAD) guidelines', *Critical Care Medicine*, vol. 41, no. 9, pp. S116-S27.

Banerjee, R., Naessens, J., Seferian, E., Gajic, O., Moriarty, J., Johnson, M. & Meltzer, D. 2011, 'Economic implications of nighttime attending intensivist coverage in a medical intensive care unit', *Critical Care Medicine*, vol. 39, no. 6, pp. 1257-62.

Barker, R. & Flint, N. 2010, 'Consequences of time of discharge from intensive care on mortality and readmission rates in a UK university teaching hospital', *Intensive Care Medicine*, vol. 36, no. 3, p. S164.

Barletta, J., Bruno, J., Buckley, M. & Cook, D. 2016, 'Stress ulcer prophylaxis', *Critical Care Medicine*, vol. 44, no. 7, pp. 1395-405.

Barnett, A., Graves, N., Rosenthal, V., Salomao, R. & Rangel ‐ Frausto, M. 2010, 'Excess length of stay due to central line‐associated bloodstream infection in intensive care units in Argentina, Brazil, and Mexico', *Infection Control and Epidemiology*, vol. 31, no. 11, pp. 1106-14.

Beck, C. 1995, 'The effects of postpartum depression on maternal-infant interaction: a meta-analysis', *Nursing research*, vol. 44, no. 5, pp. 298-305.

Ben-Tovim, D. 2010, 'Hospital mortality ratios. Death is final: getting the balance right.', *BMJ*, vol. 340, p. c2741.

Bennett, S. 2009, 'Design, organization and staffing of the intensive care unit', *Surgery (Oxford)*, vol. 27, no. 5, pp. 190-4.

Bennett, S. 2015, 'Design, organization and staffing of the intensive care unit', *Surgery (Oxford)*, vol. 33, no. 4, pp. 148-52.

Berenholtz, S., Pham, J., Thompson, D., Needham, D., Lubomski, H., Hyzy, R., Welsh, R., Cosgrove, S., Sexton, B., Colantuoni, E., Watson, S., Goeschel, C. & Pronovost, P. 2011, 'Collaborative cohort study of an intervention to reduce ventilator-associated pneumonia in the intensive care unit', *Infection Control and Hospital Epidemiology*, vol. 32, no. 4, pp. 305-14.

Bergmann, A. 2010, 'Venous thromboembolism risk and prophylaxis in hospitalised medically ill patients', *Blood Coagulation, Fibrinolysis and Cellular Haemostasis*, vol. 103, pp. 736-48.

Bertolini, G., Rossi, C., Brazzi, L., Radrizzani, D., Rossi, G., Arrighi, E. & Simini, B. 2003, 'The relationship between labour cost per patient and the size of intensive care units: a multicentre prospective study', *Intensive Care Medicine*, vol. 29, no. 12, pp. 2307-11.

Bice, T. 2016, 'ICU readmissions: good for reflection on performance but not a reflection of quality', *Critical Care Medicine*, vol. 44, no. 9, pp. 1790-1.

Bingham, M., Ashley, J., De Jong, M. & Swift, C. 2010, 'Implementing a unit-level intervention to reduce the probability of ventilator-associated pneumonia', *Nurs Res*, vol. 59, no. 1 Suppl, pp. S40-7.

Bisbal, M., Pauly, V., Gainnier, M., Forel, J.M., Roch, A., Guervilly, C., Demory, D., Arnal, J.M., Michel, F. & Papazian, L. 2012, 'Does admission during morning rounds increase the mortality of patients in the medical ICU?', *Chest*, vol. 142, no. 5, pp. 1179-84.

Blackwood, B., Alderdice, F., Burns, K., Cardwell, C., Lavery, G. & O'Halloran, P. 2011, 'Use of weaning protocols for reducing duration of mechanical ventilation in critically ill adult patients: Cochrane systematic review and meta-analysis', *BMJ*, vol. 342, p. c7237.

Blegen, M., Goode, C., Spetz, J., Vaughn, T. & Park, S. 2011, 'Nurse staffing effects on patient outcomes: safety-net and non-safety-net hospitals', *Medical Care*, vol. 49, no. 4, pp. 406-14.

Blot, S., Serra, M., Koulenti, D., Lisboa, T., Deja, M., Myrianthefs, P., Manno, E., Diaz, E., Topeli, A., Martin-Loeches, I. & Rello, J. 2011, 'Patient to nurse ratio and risk of ventilator-associated pneumonia in critically ill patients', *American Journal of Critical Care*, vol. 20, no. 1, pp. e1-e9.

Boddi, M., Barbani, F., Abbate, R., Bonizzoli, M., Batacchi, S., Lucente, E., Chiostri, M., Gensini, G.F. & Peris, A. 2010, 'Reduction in deep vein thrombosis incidence in intensive care after a clinician education program', *Journal of Thrombosis and Haemostasis*, vol. 8, no. 1, pp. 121-8.

Boddi, M., Cecchi, A., Bonizzoli, M., Barbani, F., Franci, A., Anichini, V., Batacchi, S., Parodo, J., Gensini, G. & Peris, A. 2014, 'Follow-up after four-year quality improvement program to prevent inferior limb deep vein thrombosis in intensive care unit', *Thrombosis Research*, vol. 134, no. 3, pp. 578-83.

Bonneterre, V., Liaudy, S., Chatellier, G., Lang, T. & de Gaudemaris, R. 2008, 'Reliability, validity, and health issues arising from questionnaires used to measure Psychosocial and Organizational Work Factors (POWFs) among hospital nurses: a critical review', *Journal of Nursing Measurement*, vol. 16, no. 3, pp. 207-30.

Borgert, M., Goossens, A. & Dongelmans, D. 2015, 'What are effective strategies for the implementation of care bundles on ICUs: a systematic review', *Implementation Science*, vol. 10, no. 1, pp. 119-30.

Bowling, A. 2014, *Research Methods in Health: Investigating Health and Health Services*, McGraw-Hill Education Berkshire, United Kingdom.

Braithwaite, J. & Westbrook, M. 2005, 'Rethinking clinical organisational structures: an attitude survey of doctors, nurses and allied health staff in clinical directorates', *Journal of Health Services Research & Policy*, vol. 10, no. 1, pp. 10-7.

Braithwaite, J., Westbrook, M., Hindle, D., Iedema, R. & Black, D. 2006, 'Does restructuring hospitals result in greater efficiency-an empirical test using diachronic data', *Health Services Management Research*, vol. 19, no. 1, pp. 1-12.

Brand, C., Landgren, F., Staley, C., Tropea, J., Liew, D., Bohensky, M. & Gorelik, A. 2013, *Hospital Mortality Indicator Review. Commissioned by the Australian Commission on Safety and Quality in Health Care.*, Melbourne University, Melbourne pp. 1-79.

Brasel, K. 2008, 'Can we safely discharge patients from the intensive care unit after hours?', *Critical Care Medicine*, vol. 36, no. 8, pp. 2443-4.

Braun, P., Mende, H., Bause, H., Bloos, F., Geldner, G., Kastrup, M., Kuhlen, R., Markewitz, A., Martin, J., Quintel, M., Steinmeier-Bauer, K., Waydhas, C. & Spies, C. 2010, 'Quality indicators in intensive care medicine: why? Use or burden for the intensivist', *German Medical Science*, vol. 8, pp. 1-20.

Braungardt, T. & Fought, S. 2008, 'Leading change during an inpatient critical care unit expansion', *Journal of Nursing Administration*, vol. 38, no. 11, pp. 461-7.

Breau, M. & Rhéaume, A. 2014, 'The relationship between empowerment and work environment on job satisfaction, intent to leave, and quality of care among ICU nurses', *Dynamics*, vol. 25, no. 3, pp. 16-4.

Bredesen, I., Bjøro, K., Gunningberg, L. & Hofoss, D. 2015, 'Patient and organisational variables associated with pressure ulcer prevalence in hospital settings: a multilevel analysis', *BMJ Open*, vol. 5, no. 8, p. p.e007584.

Brett, A. 2011, 'Critical care outcomes: current and future issues', *Current Opinion in Critical Care*, vol. 17, no. 5, pp. 493-4.

Brewer, C., Kovner, C., Djukic, M., Fatehi, F., Greene, W., Chacko, T. & Yang, Y. 2016, 'Impact of transformational leadership on nurse work outcomes', *Journal of Advanced Nursing*, vol. 72, no. 11, pp. 2879-93.

Bria, M., Spânu, F., Băban, A. & Dumitraşcu, D. 2014, 'Maslach Burnout Inventory–General Survey: factorial validity and invariance among Romanian healthcare professionals', *Burnout Research*, vol. 1, no. 3, pp. 103-11.

Brown, S., Ratcliffe, S., Kahn, J. & Halpern, S. 2012, 'The epidemiology of intensive care unit readmissions in the United States', *American Journal of Respiratory and Critical Care Medicine*, vol. 185, no. 9, pp. 955-64.

Brown, T. 2003, ''Confirmatory factor analysis of the Penn State Worry Questionnaire: multiple factors or method effects?'', *Behaviour Research and Therapy*, vol. 41, no. 12, pp. 1411-26.

Buchan, J., Seccombe, I., Gershlick, B. & Charlesworth, A. 2017, *In Short Supply: Pay Policy and Nurse Numbers*, The Health Foundation, London.

Burke, R. 2003, 'Hospital restructuring, workload, and nursing staff satisfaction and work experiences', *The Health Care Manager*, vol. 22, no. 2, pp. 99-107.

Burke, R.J., Ng, E.W. & Wolpin, J. 2011, 'Hospital restructuring and downsizing: Effects on nursing staff well-being and perceived hospital functioning', *Europe’s Journal of Psychology*, vol. 7, no. 1, pp. 81-98.

Burmeister, E. & Aitken, L.M. 2012, 'Sample size: How many is enough?', *Australian Critical Care*, vol. 25, no. 4, pp. 271-4.

Burrell, A., McLaws, M., Murgo, M., Calabria, E., Pantle, A. & Herkes, R. 2011, 'Aseptic insertion of central venous lines to reduce bacteraemia', *Medical Journal of Australia*, vol. 194, no. 11, pp. 583-7.

Burston, S., Chaboyer, W. & Gillespie, B. 2014, 'Nurse ‐ sensitive indicators suitable to reflect nursing care quality: a review and discussion of issues', *Journal of clinical nursing*, vol. 23, no. 13-14, pp. 1785-95.

Byrnes, M., Schuerer, D., Schallom, M., Sona, C., Mazuski, J., Taylor, B., McKenzie, W., Thomas, J., Emerson, J., Nemeth, J., Bailey, R., Boyle, W., Buchman, T. & Coopersmith, C. 2009, 'Implementation of a mandatory checklist of protocols and objectives improves compliance with a wide range of evidence-based intensive care unit practices', *Critical Care Medicine*, vol. 37, no. 10, pp. 2775-81.

CACCN 2011, 'Canadian Association of Critical Care Nurses: Position statement on the structure of critical care units', *Dynamics*, vol. 22, no. 2, pp. 13-4.

Cai, C. & Zhou, Z. 2009, 'Structural empowerment, job satisfaction, and turnover intention of Chinese clinical nurses', *Nurs Health Sci*, vol. 11, no. 4, pp. 397-403.

Callicutt, D., Norman, K., Smith, L., Nichols, A. & Kring, D. 2011, 'Building an engaged and certified nursing workforce', *Nursing Clinics of North America*, vol. 46, no. 1, pp. 81-7.

Capuzzo, M., Moreno, R. & Alvisi, R. 2010, 'Admission and discharge of critically ill patients', *Current Opinion in Critical Care*, vol. 16, no. 5, pp. 499-504.

Cardoso, L., Grion, C., Matsuo, T., Anami, E., Kauss, I., Seko, L. & Bonametti, A. 2011, 'Impact of delayed admission to intensive care units on mortality of critically ill patients: a cohort study', *Critical Care*, vol. 15, no. 1, p. R28.

Carlson, R., Weiland, D. & Srivathsan, K. 1996, 'Does a full-time, 24-hour intensivist improve care and efficiency?', *Critical Care Clinics*, vol. 12, no. 3, pp. 525-51.

Carney, M. 2011, 'Influence of organizational culture on quality healthcare delivery', *International Journal of Health Care Quality Assurance*, vol. 24, no. 7, pp. 523-39.

Carrothers, K., Barr, J., Spurlock, B., Ridgely, S., Damberg, C. & Ely, W. 2013, 'Contextual issues influencing implementation and outcomes associated with an integrated approach to managing pain, agitation, and delirium in adult ICUs', *Critical Care Medicine*, vol. 41, no. 9, pp. S128-S35.

Catell, R. & Vogelmann, S. 1977, 'A comprehensive trial of the scree and KG criteria for determining the number of factors', *Multivariate Behavioral Research*, vol. 12, no. 3, pp. 289-325.

Chacko, B., Thomas, K., David, T., Paul, H., Jeyaseelan, L. & Peter, J. 2017, 'Attributable cost of a nosocomial infection in the intensive care unit: A prospective cohort study', *World Journal of Critical Care Medicine*, vol. 6, no. 1, pp. 79-84.

Chan, A. & Huak, C. 2004, 'Influence of work environment on emotional health in a health care setting', *Occupational Medicine*, vol. 54, no. 3, pp. 207-12.

Chan, K., Tan, C., Fang, C., Tsai, C., Hou, C., Cheng, K. & Lee, M. 2009, 'Readmission to the intensive care unit: an indicator that reflects the potential risks of morbidity and mortality of surgical patients in the intensive care unit', *Surgery Today*, vol. 39, no. 4, pp. 295-9.

Chan, Z., Tam, W., Lung, M., Wong, W. & Chau, C. 2012, 'A systematic literature review of nurse shortage and the intention to leave', *Journal of Nursing Management*, vol. 21, no. 4, pp. 1-9.

Chang, L., Liu, P., Huang, Y., Yang, S. & Chang, W. 2011, 'Risk factors associated with unplanned endotracheal self-extubation of hospitalized intubated patients: a 3-year retrospective case-control study', *Applied Nursing Research*, vol. 24, no. 3, pp. 188-92.

Chang, L., Wang, K. & Chao, Y. 2008, 'Influence of physical restraint on unplanned extubation of adult intensive care patients: a case-control study', *American Journal of Critical Care*, vol. 17, no. 5, pp. 408-15.

Chant, C., Smith, O., Marshall, J. & Friedrich, J. 2011, 'Relationship of catheter-associated urinary tract infection to mortality and length of stay in critically ill patients: a systematic review and meta-analysis of observational studies', *Critical Care Medicine*, vol. 39, no. 5, pp. 1167-73.

Chassin, M. & Loeb, J. 2013, 'High-reliability health care: getting there from here', *Milbank Quarterly*, vol. 91, no. 3, pp. 459-90.

Checkley, W., Martin, G., Brown, S., Chang, S., Dabbagh, O., Fremont, R., Girard, T., Rice, T., Howell, M., Johnson, S., O'Brien, J., Park, P., Pastores, S., Patil, N., Pietropaoli, A., Putman, M., Rotello, L., Siner, J., Sajid, S., Murphy, D. & Sevransky, J. 2014, 'Structure, process, and annual ICU mortality across 69 centers: United States Critical Illness and Injury Trials Group critical illness outcomes study', *Critical Care Medicine*, vol. 42, no. 2, pp. 344-56.

Chen, C., Chan, K., Fong, Y., Hsing, S., Cheng, A., Sung, M., Su, M. & Cheng, K. 2010, 'Age is an important predictor of failed unplanned extubation', *International Journal of Gerontology*, vol. 4, no. 3, pp. 120-9.

Chen, G., Kirkman, B., Kanfer, R., Allen, D. & Rosen, B. 2007, 'A multilevel study of leadership, empowerment, and performance in teams', *Journal of Applied Psychology*, vol. 92, no. 2, pp. 331-46.

Chen, H. 2012, 'Exploring influence on the successful unplanned extubation in Taiwan', *Sigma Theta Tau International's 23rd International Nursing Research Congress*, STTI, Brisbane, Australia.

Cherry, R., West, C., Hamilton, M., Rafferty, C., Hollenbeak, C. & Caputo, G. 2011, 'Reduction of central venous catheter associated blood stream infections following implementation of a resident oversight and credentialing policy', *Patient Safety in Surgery* vol. 5, no. 15, pp. 1-8.

Cho, E., Sloane, D., Kim, E., Kim, S., Choi, M., Yoo, I., Lee, H. & Aiken, L. 2014, 'Effects of nurse staffing, work environments, and education on patient mortality: an observational study', *International Journal of Nursing Studies*, vol. 52, no. 2, pp. 535-42.

Cho, H., Lee, Y., Kim, H. & Sim, B. 2012, 'Comparison of related characteristics between unplanned and planned extubation of patients in medical intensive unit', *Korean Journal of Adult Nursing*, vol. 24, no. 5, pp. 509-19.

Cho, S., Hwang, J. & Kim, J. 2008, 'Nurse staffing and patient mortality in intensive care units', *Nursing Research*, vol. 57, no. 5, pp. 322-30.

Cho, S., June, K., Kim, Y., Cho, Y., Yoo, C., Yun, S. & Sung, Y. 2009, 'Nurse staffing, quality of nursing care and nurse job outcomes in intensive care units', *Journal of Clinical Nursing*, vol. 18, no. 12, pp. 1729-37.

Choi, J., Kim, E. & Kim, S. 2014, 'Effects of empowerment and job satisfaction on nursing performance of clinical nurses', *Journal of the Korean Academy of Nursing Administration*, vol. 20, no. 4, pp. 426-36.

Christianson, M., Sutcliffe, K., Miller, M. & Iwashyna, T. 2011, 'Becoming a high reliability organization', *Critical Care*, vol. 15, no. 6, pp. 314-19.

Chrusch, C., Olafson, K., McMillan, P., Roberts, D. & Gray, P. 2009, 'High occupancy increases the risk of early death or readmission after transfer from intensive care', *Critical Care Medicine*, vol. 37, no. 10, pp. 2753-8.

Chuang, C., Tseng, P., Lin, C., Lin, K. & Chen, Y. 2016, 'Burnout in the intensive care unit professionals: a systematic review', *Medicine*, vol. 95, no. 50, p. e5629.

Churpek, M., Yuen, T. & Edelson, D. 2013, 'Delayed intensive care unit transfer is associated with increased mortality in ward patients', *American Journal of Respiratory and Critical Care Medicine*, vol. 187, p. A6074.

CICM 2011, *Minimum Standards for Intensive Care Units IC-1*, College of Intensive Care Medicine, Melbourne, Australia.

CICM 2014, *Minimum Standards for Intensive Care Units Seeking Accreditation for Training in Intensive Care Medicine* College of Intensive Care Medicine, Melbourne, Australia.

Clarke, S. 2009, 'Three metaphors and a (mis)quote: thinking about staffing-outcomes research, health policy and the future of nursing', *Journal of Nursing Management* vol. 17, no. 2, pp. 151-4.

Clarke, T., Mackinnon, E., England, K., Burr, G., Fowler, S. & Fairservice, L. 1999, 'A review of intensive care nurse staffing practices overseas: what lessons for Australia?', *Australian Critical Care*, vol. 12, no. 3, pp. 109-18.

Clarkson, D. 2013, 'The role of care bundles in healthcare', *British Journal of Healthcare Management*, vol. 19, no. 2, pp. 63-8.

Clay-Williams, R., Nosrati, H., Cunningham, F., Hillman, K. & Braithwaite, J. 2014, 'Do large-scale hospital-and system-wide interventions improve patient outcomes: a systematic review', *BMC Health Services Research*, vol. 14, no. 1, pp. 369-94.

Clemens, T., Michelsen, K., Commers, M., Garel, P., Dowdeswell, B. & Brand, H. 2014, 'European hospital reforms in times of crisis: aligning cost containment needs with plans for structural redesign?', *Health Policy*, vol. 117, no. 1, pp. 6-14.

Clendon, J. & Gibbons, V. 2015, '12h shifts and rates of error among nurses: a systematic review', *International Journal of Nursing Studies*, vol. 52, no. 7, pp. 1231-42.

Coetzee, S., Klopper, H., Ellis, S. & Aiken, L. 2013, 'A tale of two systems—nurses practice environment, well being, perceived quality of care and patient safety in private and public hospitals in South Africa: a questionnaire survey', *International Journal of Nursing Studies*, vol. 50, no. 2, pp. 162-73.

Cohen, J. 1998, *Statistical Power Analysis for the Behavioural Sciences*, 2nd edn, Lawrence Erlbaum Associates, New Jersey.

Cohen, J. 2013, *Statistical power analysis for the behavioral sciences*, 2nd edn, Academic Press, New York.

Cohen, J. & Cohen, P. 1983, *Applied Multiple Regression/Correlation Research for the Behavioral Sciences*, Erlbaum, Hillsdale, New Jersey.

Conway, L., Pogorzelska, M., Larson, E. & Stone, P. 2012, 'Adoption of policies to prevent catheter-associated urinary tract infections in United States intensive care units', *American Journal of Infection Control*, vol. 40, no. 8, pp. 705-10.

Cope, D. 2014, 'Analysis and use of different research review approaches in nursing', *Oncology Nursing Forum*, vol. 41, no. 2, pp. 207-8.

Corke, C., de Leeuw, E., Lo, S. & George, C. 2009, 'Predicting future intensive care demand in Australia', *Critical Care and Resuscitation*, vol. 11, no. 4, pp. 257-60.

Costa, D. & Kahn, J. 2016, 'Organizing critical care for the 21st century', *JAMA*, vol. 315, no. 8, pp. 751-2.

Coyer, F., Gardner, A., Doubrovsky, A., Cole, R., Ryan, F., Allen, C. & McNamara, G. 2015, 'Reducing pressure injuries in critically Ill patients by using a patient skin integrity care bundle (Inspire)', *American Journal of Critical Care*, vol. 24, no. 3, pp. 199-209.

Cranley, L., Doran, D., Tourangeau, A., Kushniruk, A. & Nagle, L. 2012, 'Recognizing and responding to uncertainty: a grounded theory of nurses' uncertainty', *Worldviews on Evidence-Based Nursing*, vol. 9, no. 3, pp. 149-58.

Cremasco, M., Wenzel, F., Zanei, S. & Whitaker, I. 2013, 'Pressure ulcers in the intensive care unit: the relationship between nursing workload, illness severity and pressure ulcer risk', *Journal of Clinical Nursing*, vol. 22, no. 15, pp. 2183-91.

Crippen, D. 2013, *ICU resource allocation in the new millennium: will we say "no"?*, Springer Science & Business Media, Pittsburgh.

Cullen, D., Civetta, J., Briggs, B. & Ferrara, L. 1974, 'Therapeutic intervention scoring system: a method for quantitative comparison of patient care', *Critical Care Medicine*, vol. 2, no. 2, pp. 57-60.

Cummings, G., Hayduk, L. & Estabrooks, C. 2005, 'Mitigating the impact of hospital restructuring on nurses: the responsibility of emotionally intelligent leadership', *Nursing Research*, vol. 54, no. 1, pp. 2-12.

Curry, K., Cobb, S., Kutash, M. & Diggs, C. 2008, 'Characteristics associated with unplanned extubations in a surgical intensive care unit', *American Journal of Critical Care*, vol. 17, no. 1, pp. 45-51.

Curtis, J., Cook, D., Wall, R., Angus, D., Bion, J., Kacmarek, R., Kane-Gill, S., Kirchhoff, K., Levy, M., Mitchell, P., Moreno, R., Pronovost, P. & Puntillo, K. 2006, 'Intensive care unit quality improvement: a “how-to” guide for the interdisciplinary team', *Critical Care Medicine*, vol. 34, no. 1, pp. 211-8.

da Costa, B., Cevallos, M., Altman, D., Rutjes, A. & Egger, M. 2012, 'Uses and misuses of the STROBE statement', *BMJ Open*, vol. 1, no. 1, pp. 1-7.

Dabbagh, O., Adams, L., Haddadin, S., Jaouni, H., Karpman, C., Nusair, M., Botdorf, J., Spear, J., Cohen, S., Matz, E. & Hall, L. 2009, 'Effect of time of admission on compliance with deep vein thrombosis prophylaxis in a tertiary medical intensive care unit', *Journal of Thrombosis and Haemostasis*, vol. 7, no. 6, pp. 950-4.

Dall'Ora, C., Griffiths, P., Ball, J., Simon, M. & Aiken, L. 2015, 'Association of 12 h shifts and nurses' job satisfaction, burnout and intention to leave: findings from a cross-sectional study of 12 European countries', *BMJ Open*, vol. 5, no. 9, p. e008331.

Danckers, M., Grosu, H., Jean, R., Cruz, R., Fidellaga, A., Han, Q., Awerbuch, E., Jadhav, N., Rose, K. & Khouli, H. 2013, 'Nurse-driven, protocol-directed weaning from mechanical ventilation improves clinical outcomes and is well accepted by intensive care unit physicians', *Journal of Critical Care*, vol. 28, no. 4, pp. 433-41.

Daneman, N., Scales, D., Lawless, B., Muscedere, J., Blount, V. & Fowler, R. 2013, 'Infection prevention and control in the intensive care unit: open versus closed models of care', *Infection Control and Hospital Epidemiology*, vol. 34, no. 8, pp. 867-71.

Darmon, M., Azoulay, E., Fulgencio, J., Garrigues, B., Gouzes, C., Moine, P., Villers, D., Teboul, V., le Gall, J. & Chevret, S. 2011, 'Procedure volume is one determinant of center effect in mechanically ventilated patients', *European Respiratory Journal*, vol. 37, no. 2, pp. 364-70.

Daud-Gallotti, R., Costa, S., Guimarães, T., Padilha, K., Inoue, E., Vasconcelos, T., Rodrigues, F., Barbosa, E., Figueiredo, W. & Levin, A. 2012, 'Nursing workload as a risk factor for healthcare associated infections in ICU: a prospective study', *PloS one*, vol. 7, no. 12, pp. e52342 1-7.

Dawson, A., Stasa, H., Roche, M., Homer, C. & Duffield, C. 2014, 'Nursing churn and turnover in Australian hospitals: nurses perceptions and suggestions for supportive strategies', *BMC Nursing*, vol. 13, no. 1, pp. 1-10.

de Groot, R., Dekkers, O., Herold, I., de Jonge, E. & Arbous, M. 2011, 'Risk factors and outcomes after unplanned extubations on the ICU: a case-control study', *Critical Care*, vol. 15, no. 1, p. R19.

de Lange, D., Wunsch, H. & Kesecioglu, J. 2015, 'Comparing intensive care units by size or level', *Intensive Care Medicine*, vol. 41, no. 2, pp. 357-9.

de Vos, M., Graafmans, W., Keesman, E., Westert, G. & van der Voort, P. 2007, 'Quality measurement at intensive care units: which indicators should we use?', *Journal of Critical Care*, vol. 22, no. 4, pp. 267-74.

Debajyoti, P., Leed, A. & Thomas, E. 2008, 'Inpatient unit flexibility: design characteristics of a successful flexible unit', *Environment and Behavior*, vol. 40, no. 2, pp. 205-32.

Decker, H. 2012, 'A Pragmatic Approach to Model, Measure and Maintain the Quality of Information in Databases', paper presented to the *AHRC workshop on Data Quality*, Hatfield.

Dedman, G., Nowak, M. & Klass, D. 2011, 'The dimensions of efficiency and effectiveness of clinical directors: perceptions of clinical directors and senior management in Western Australian public teaching hospitals', *The International Journal of Clinical Leadership*, vol. 17, no. 2, pp. 61-71.

Deeks, J., Dinnes, J., D'Amico, R., Sowden, A., Sakarovitch, C., Song, F., Petticrew, M. & Altman, D. 2003, 'Evaluating non-randomised intervention studies', *Health Technology Assessment*, vol. 7, no. 27, pp. iii-x.

DHHS 2009, *ICD-9-CM Official Guidelines for Coding and Reporting*, United States Federal Government, Washington, pp. 1-34.

Dicosmo, B. 1999, ' Strict ICU admission/discharge criteria result in decreased admissions, shorter stays and lower costs', *CHEST*, vol. 116, no. 4, pp. 238S-9S.

Dietz, A., Pronovost, P., Mendez-Tellez, P., Wyskiel, R., Marsteller, J., Thompson, D. & Rosen, M. 2014, 'A systematic review of teamwork in the intensive care unit: What do we know about teamwork, team tasks, and improvement strategies?', *Journal of Critical Care*, vol. 29, no. 6, pp. 908-14.

Dimick, J., Pronovost, P., Heitmiller, R. & Lipsett, P. 2001, 'Physician staffing is associated with decreased length of stay, hospital costs and complications after oesophageal resection', *Critical Care Medicine* vol. 29, no. 4, pp. 753-8.

Dirik, H. & Seren, S. 2017, 'The influence of authentic leadership on safety climate in nursing', *Journal of Nursing Management*, vol. 25, no. 5, pp. 392-401.

Diya, L., Van den Heede, K., Sermeus, W. & Lesaffre, E. 2012, 'The relationship between in-hospital mortality, readmission into the intensive care nursing unit and/or operating theatre and nurse staffing levels', *Journal of Advanced Nursing*, vol. 68, no. 5, pp. 1073-82.

Djukic, M., Kovner, C., Brewer, C., Fatehi, K. & Cline, D. 2012, 'Work environment factors other than staffing associated with nurses' ratings of patient care quality', *Journal of Nursing Administration*, vol. 42, no. 10, pp. S17-S26.

Djukic, M., Kovner, C., Budin, W.C. & Norman, R. 2010, 'Physical work environment: testing an expanded model of job satisfaction in a sample of registered nurses', *Nursing Research*, vol. 59, no. 6, pp. 441-51.

Dodek, P. 2014, 'Volume-outcome relationships in critical care: understanding the mechanism', *American Journal of Respiratory and Critical Care Medicine*, vol. 190, no. 6, pp. 601-3.

Dodek, P., Chanques, G., Brown, G., Norena, M., Grubisic, M., Wong, H. & Jaber, S. 2012, 'Role of organisational structure in implementation of sedation protocols: a comparison of Canadian and French ICUs', *BMJ Quality & Safety*, vol. 21, no. 9, pp. 715-21.

Dodek, P., Keenan, S., Norena, M., Martin, C. & Wong, H. 2010, 'Structure, process, and outcome of all intensive care units within the province of British Columbia, Canada', *Journal of Intensive Care Medicine*, vol. 25, no. 3, pp. 149-55.

Dodek, P., Keenan, S., Norena, M. & Wong, H. 2010, 'Review of a large clinical series: structure, process, and outcome of all intensive care units within the province of British Columbia, Canada', *Journal of Intensive Care Medicine*, vol. 25, no. 3, pp. 149-55.

Dodek, P., Norena, M., Wong, H., Keenan, S. & Martin, C. 2015, 'Assessing the influence of intensive care unit organizational factors on outcomes in Canada: is there residual confounding?', *Journal of Intensive Care Medicine*, vol. 30, no. 7, pp. 413-9.

Dodek, P., Wong, H., Jaswal, D., Heyland, D., Cook, D., Rocker, G., Kutsogiannis, D., Dale, C., Fowler, R. & Ayas, N. 2011, 'Organizational and safety culture in Canadian intensive care units: Relationship to size of intensive care unit and physician management model', *Journal of Critical Care*, vol. 27, no. 1, pp. 11-7.

Doerr, F. & Hekmat, K. 2014, 'ICU mortality should be the study endpoint for intensive care unit scoring systems', *Scandinavian Cardiovascular Journal*, vol. 48, no. 4, pp. 256-47.

Donabedian, A. 1988, 'The quality of care: how can it be assessed?', *JAMA*, vol. 260, no. 12, pp. 1743-8.

Donabedian, A. 2005, 'Evaluating the quality of medical care', *Milbank Quarterly*, vol. 83, no. 4, pp. 691-729.

dos Santos Alves, D., da Silva, D. & de Brito Guirardello, E. 2016, 'Nursing practice environment, job outcomes and safety climate: a structural equation modelling analysis', *Journal of Nursing Management*, vol. 25, no. 1, pp. 46-55.

Drake, R. 2014, 'The nurse rostering problem: from operational research to organizational reality?', *Journal of Advanced Nursing*, vol. 70, no. 4, pp. 800-10.

Dreyer, N., Tunis, S., Berger, M., Ollendorf, D., Mattox, P. & Gliklich, R. 2010, 'Why observational studies should be among the tools used in comparative effectiveness research', *Health Affairs*, vol. 29, no. 10, pp. 1818-25.

Duff, J., Walker, K. & Omari, A. 2011, 'Translating venous thromboembolism prevention evidence into practice: a multidisciplinary evidence implementation project', *Worldviews on Evidence ‐ Based Nursing*, vol. 8, no. 1, pp. 30-9.

Duffield, C., Diers, D., O'Brien-Pallas, L., Aisbett, C., Roche, M., King, M. & Aisbett, K. 2010, 'Nursing staffing, nursing workload, the work environment and patient outcomes', *Applied Nursing Research*, vol. In Press, Corrected Proof.

Duffield, C., Diers, D., O'Brien-Pallas, L., Aisbett, C., Roche, M., King, M. & Aisbett, K. 2011, 'Nursing staffing, nursing workload, the work environment and patient outcomes', *Applied Nursing Research*, vol. 24, no. 4, pp. 244-55.

Duffield, C., Kearin, M., Johnston, J. & Leonard, J. 2007, 'The impact of hospital structure and restructure of the nursing workforce', *Australian Journal of Advanced Nursing* vol. 24, no. 3, pp. 43-6.

Duffield, C. & O'brien-Pallas, L. 2002, 'The nursing workforce in Canada and Australia: two sides of the same coin', *Australian Health Review*, vol. 25, no. 2, pp. 136-44.

Duffield, C., Roche, M., Blay, N. & Stasa, H. 2010, 'Nursing unit managers, staff retention and the work environment', *Journal of Clinical Nursing*, vol. 20, no. 1-2, pp. 23-33.

Duffield, C., Roche, M., Blay, N., Thoms, D. & Stasa, H. 2011, 'The consequences of executive turnover', *Journal of Research in Nursing*, vol. 16, no. 6, pp. 503-14.

Duffield, C., Roche, M., Dimitrelis, S., Homer, C. & Buchan, J. 2015, 'Instability in patient and nurse characteristics, unit complexity and patient and system outcomes', *Journal of Advanced Nursing*, vol. 71, no. 6, pp. 1288-98.

Duffield, C., Roche, M., O'Brien-Pallas, L., Catling-Paull, C. & King, M. 2009, 'Staff satisfaction and retention and the role of the Nursing Unit Manager', *Collegian: Royal College of Nursing, Australia*, vol. 16, no. 1, pp. 11-7.

Duffield, C., Roche, M., O'Brien-Pallas, L., Diers, D., Aisbett, C., King, M., Aisbett, K. & Hall, J. 2007, *Glueing it Together: Nurses, Their Work Environment and Patient Safety*, Centre for Health Services Management, University of Technology, Sydney, Australia.

Duke, G., Santamaria, J., Shann, F. & Stow, P. 2005, 'Outcome-based clinical indicators for intensive care medicine', *Anaesthesia and Intensive Care*, vol. 33, no. 3, pp. 303-4.

Durairaj, L., Torner, J., Chrischilles, E., Vaughan Sarrazin, M., Yankey, J. & Rosenthal, G. 2005, 'Hospital volume-outcome relationships among medical admissions to ICUs', *CHEST*, vol. 128, no. 3, pp. 1682-9.

Eager, K. 2006, *The cost of intensive care in NSW – adult intensive care, New South Wales Department of Health*, Universtity of Wollongong Sydney.

Edbrooke, D., Minelli, C., Mills, G., Iapichino, G., Pezzi, A., Corbella, D., Jacobs, P., Lippert, A., Wiis, J., Pesenti, A., Patroniti, N., Pirracchio, R., Payen, D., Gurman, G., Bakker, J., Kesecioglu, J., Hargreaves, C., Cohen, S., Baras, M., Artigas, A. & Sprung, C. 2011, 'Implications of ICU triage decisions on patient mortality: a cost-effectiveness analysis', *Critical Care*, vol. 15, no. 1, p. R56.

Einav, S., O'Connor, M. & Chavez, L. 2016, 'Visit to intensive care of 2050', *Intensive Care Medicine*, vol. 43, no. 1, pp. 154-5.

Elliott, D., Aitken, L. & Chaboyer, W. 2011, *ACCCN's Critical Care Nursing 2nd Ed.*, Elsevier, Chatswood, Australia.

Elliott, M., Worrall-Carter, L. & Page, K. 2014, 'Intensive care readmission: a contemporary review of the literature', *Intensive and Critical Care Nursing*, vol. 30, no. 3, pp. 121-37.

Elliott, R., McKinley, S. & Fox, V. 2008, 'Quality Improvement program to reduce the prevalence of pressure ulcers in an intensive care unit', *American Journal of Critical Care*, vol. 17, no. 4, pp. 328-34.

Elmufdi, F. & Weinert, C. 2015, 'Decreasing failure-to-rescue events in the era of rapid response systems', *Clinical Pulmonary Medicine*, vol. 22, no. 5, pp. 223-9.

Eriksson, C., Stoner, R., Eden, K., Newgard, C. & Guise, J. 2017, 'The association between hospital capacity strain and inpatient outcomes in highly developed countries: a systematic review', *Journal of General Internal Medicine*, vol. 32, no. 6, pp. 686-96.

Estabrooks, C., Midodzi, W., Cummings, G., Ricker, K. & Giovannetti, P. 2005, 'The impact of hospital nursing characteristics on 30-day mortality', *Nursing Research*, vol. 54, no. 2, pp. 74-84.

Evans, D. 2003, 'Hierarchy of evidence: a framework for ranking evidence evaluating healthcare interventions', *Journal of Clinical Nursing*, vol. 12, no. 1, pp. 77-84.

Fairchild, R., Everly, M., Bozarth, L., Bauer, R., Walters, L., Sample, M. & Anderson, L. 2013, 'A qualitative study of continuing education needs of rural nursing unit staff: the nurse administrator's perspective', *Nurse Education Today*, vol. 33, no. 4, pp. 364-9.

Fairman, J. & Kagan, S. 1999, 'Creating critical care: the case of the hospital of the University of Pennsylvania, 1950-1965', *Advances in Nursing Science*, vol. 22, no. 1, pp. 63-77.

Falk, A. & Wallin, E. 2016, 'Quality of patient care in the critical care unit in relation to nurse patient ratio: a descriptive study', *Intensive and Critical Care Nursing*, vol. 35, pp. 74-9.

Faulkner, J. & Laschinger, H. 2008, 'The effects of structural and psychological empowerment on perceived respect in acute care nurses', *Journal of Nursing Management*, vol. 16, no. 2, pp. 214-21.

Ferketich, S. & Verran, J. 1990, 'Internal consistency estimates of reliability', *Research in Nursing & Health*, vol. 13, no. 6, pp. 437-40.

Fernandez, R. 2015, 'Occupancy of the departments of intensive care medicine in Catalonia (Spain): a prospective, analytical cohort study', *Medicina Intensiva*, vol. 39, no. 9, pp. 537-42.

Field, A. 2013, *Discovering Statistics Using IBM SPSS Statistics*, Sage.

Fink, M. 2015, 'Integrated critical care organizations: a personal view', *Critical Care Medicine*, vol. 43, no. 10, pp. 2047-8.

Fink, M.P. 2011, 'Organized staffing directed by intensivists improves outcomes for critically ill patients', *American Journal of Transplantation*, vol. 11, no. 4, pp. 645-6.

Flaatten, H. 2012, 'The present use of quality indicators in the intensive care unit', *Acta Anaesthesiologica Scandinavica*, vol. 56, no. 9, pp. 1078-83.

Flabouris, A., Hart, G.K. & Nicholls, A. 2013, 'Accessibility of the Australian population to an ICU, and of ICUs to each other', *Critical Care and Resuscitation*, vol. 15, no. 3, p. 177.

Fonseca, T.C.d.P. & Mello, R. 2015, 'Burnout syndrome among nursing professionals of intensive units in a public hospital', *Journal of Nursing Administration*, vol. 10, no. 1, pp. 296-303.

Frankel, S. & Moss, M. 2014, 'The Effect of organizational structure and processes of care on ICU mortality as revealed by the United States Critical Illness and Injury Trials Group Critical Illness Outcomes Study', *Critical Care Medicine*, vol. 42, no. 2, pp. 463-4.

Frost, E. 1976, 'Tracing the tracheostomy', *Annals of Otology, Rhinology & Laryngology*, vol. 85, no. 5, pp. 618-24.

Gajewski, B., Boyle, D., Miller, P., Oberhelman, F. & Dunton, N. 2010, 'A multilevel confirmatory factor analysis of the Practice Environment Scale: a case study', *Nursing Research*, vol. 59, no. 2, pp. 147-53.

Galletta, M., Portoghese, I., D’Aloja, E., Mereu, A., Contu, P., Coppola, R., Finco, G. & Campagna, M. 2016, 'Relationship between job burnout, psychosocial factors and health care-associated infections in critical care units', *Intensive and Critical Care Nursing*, vol. 34, pp. 59-66.

Ganey, P. 2015, *The Influence of Nurse Work Environment on Patient, Payment and Nurse Outcomes in Acute Care Settings*, Indiana, United States.

Gantner, D., Farley, K., Bailey, M., Huckson, S., Hicks, P. & Pilcher, D. 2014, 'Mortality related to after-hours discharge from intensive care in Australia and New Zealand, 2005–2012', *Intensive Care Medicine*, vol. 40, no. 10, pp. 1528-35.

García-Olivares, P., Guerrero, J., Keough, E., Galdos, P., Carriedo, D., Murillo, F. & Rivera, A. 2016, 'Clinical factors associated with inappropriate prophylaxis of venous thromboembolic disease in critically ill patients: a single day cross-sectional study', *Thrombosis Research*, vol. 143, pp. 111-7.

Gardner, G., Duffield, C., Doubrovsky, A., Bui, U. & Adams, M. 2017, 'The structure of nursing: a national examination of titles and practice profiles', *International Nursing Review*, vol. 64, no. 2, pp. 233-41.

Garland, A. 2005, 'Improving the ICU: part 1', *CHEST*, vol. 127, no. 6, pp. 2151-64.

Garland, A. 2010, 'Figuring out what works: a need for more and better studies on the relationship between ICU organization and outcomes', *Critical Care*, vol. 14, no. 1, pp. 108-9.

Garland, A. 2013, 'Effect of collaborative care on cost variation in an intensive care unit', *American Journal of Critical Care*, vol. 22, no. 3, pp. 232-8.

Garland, A. & Connors, A. 2013, 'Optimal timing of transfer out of the intensive care unit', *American Journal of Critical Care*, vol. 22, no. 5, pp. 390-7.

Garland, A., Roberts, D. & Graff, L. 2012, 'Twenty four hour intensivist presence: a pilot study of effects on intensive care unit patients, families, doctors, and nurses', *American Journal of Respiratory and Critical Care Medicine*, vol. 185, no. 7, pp. 738-43.

Gasparino, R., de Brito Guirardello, E. & Aiken, L. 2011, 'Validation of the Brazilian version of the Nursing Work Index-Revised (B-NWI-R)', *Journal of Clinical Nursing*, vol. 20, no. 23, pp. 3494-501.

Gasperino, J. 2011, 'The Leapfrog initiative for intensive care unit physician staffing and its impact on intensive care unit performance: a narrative review', *Health Policy*, vol. 102, no. 3, pp. 223-8.

Geerts, W. 2008, 'Prevention of venous thromboembolism: American College of Chest Physicians Evidence-Based clinical practice guidelines', *Chest*, vol. 133, no. 6, pp. S381-453.

Georgiou, E., Papathanassoglou, E. & Pavlakis, A. 2015, 'Nurse-physician collaboration and associations with perceived autonomy in Cypriot critical care nurses', *Nursing in Critical Care*, vol. 22, no. 1, pp. 29-32.

Gershon, R., Stone, P., Bakken, S. & Larson, E. 2004, 'Measurement of organizational culture and climate in healthcare', *Journal of Nursing Administration*, vol. 34, no. 1, pp. 33-40.

Gifford, W., Davies, B., Graham, I., Tourangeau, A., Woodend, K. & Lefebre, N. 2013, 'Developing leadership capacity for guideline use: a pilot cluster randomized control trial', *Worldviews on Evidence-Based Nursing*, vol. 10, no. 1, pp. 51-65.

Gikopoulou, D., Tsironi, M., Lazakidou, A., Moisoglou, I. & Prezerakos, P. 2014, 'The assessment of nurses' work environment: the case of a Greek general hospital', *International Journal of Caring Sciences*, vol. 7, no. 1, pp. 269-75.

Girbes, A. & Marik, P. 2017, 'Protocols for the obvious: where does it start, and stop?', *Annals of Intensive Care*, vol. 7, no. 1, pp. 42-4.

Goldschmidt, K. & Gordin, P. 2006, 'A model of nursing care microsystems for a large neonatal intensive care unit', *Advances in Neonatal Care*, vol. 6, no. 2, pp. 81-8.

Goldsworthy, S. 2017, 'Creating exceptional critical care units: how healthy is your work environment?', *Canadian Journal of Critical Care Nursing*, vol. 28, no. 2, p. 35.

Gopal, S., Terry, L. & Corbett, C. 2010, 'Association between out of hours discharge from the ICU and subsequent readmission', *Critical Care*, vol. 14 no. Suppl 1, p. 476.

Gover, L. & Duxbury, L. 2012, 'Organizational faultlines: social identity dynamics and organizational change', *Journal of Change Management*, vol. 12, no. 1, pp. 53-75.

Grant, P. & Flanders, S. 2015, 'Venous thromboembolism prophylaxis: a path toward more appropriate use', *BMJ Quality & Safety*, vol. 24, no. 10, pp. 605-7.

Grathwohl, K. & Venticinque, S. 2008, 'Organizational characteristics of the austere intensive care unit: the evolution of military trauma and critical care medicine; applications for civilian medical care systems.', *Critical Care Medicine*, vol. 36[Suppl.], no. 7, pp. S275–S83.

Green, J. 2013, 'Patient comfort in the intensive care unit: a multicentre, binational point prevalence study of analgesia, sedation and delirium management', *Critical Care and Resuscitation*, vol. 15, no. 4, pp. 329-30.

Green, L. 2005, 'Capacity Planning and Management in Hospitals', in M. Brandeau, F. Sainfort & W. Pierskalla (eds), *Operations Research and Health Care*, vol. 70, Springer, United States, pp. 15-41.

Green, R. & Bowser, M. 2006, 'Observations from the field: sharing a literature review rubric', *Journal of Library Administration*, vol. 45, no. 1-2, pp. 185-202.

Grenvik, A. & Pinsky, M. 2009, 'Evolution of the intensive care unit as a clinical center and critical care medicine as a discipline', *Critical Care Clinics*, vol. 25, no. 1, pp. 239-50.

Griffiths, P., Dall'Ora, C., Simon, M., Ball, J., Lindqvist, R., Rafferty, A., Schoonhoven, L., Tishelman, C. & Aiken, L. 2014, 'Nurses' shift length and overtime working in 12 European countries: the association with perceived quality of care and patient safety', *Medical Care*, vol. 52, no. 11, pp. 975-81.

Groff Paris, L. & Terhaar, M. 2010, 'Using Maslow's pyramid and the national database of nursing quality indicators to attain a healthier work environment ', *The Online Journal of Issues in Nursing*, vol. 16, no. 1-13.

Grove, S. & Burns, N. 2005, *The Practice of Nursing Research: Conduct, Critique, & Utilization*, 5 edn, Elsevier Saunders, Missouri.

Guidet, B., van der Voort, P. & Csomos, A. 2017, 'Intensive care in 2050: healthcare expenditure', *Intensive Care Medicine*, vol. 43, no. 1, pp. 1-3.

Guntupalli, K., Wachtel, S., Mallampalli, A. & Surani, S. 2014, 'Burnout in the intensive care unit professionals', *Indian Journal of Critical Care Medicine* vol. 18, no. 3, pp. 139-43.

Haerkens, M., Kox, M., Lemson, J., Houterman, S., Hoeven, J. & Pickkers, P. 2015, 'Crew resource management in the intensive care unit: a prospective 3 ‐ year cohort study', *Acta Anaesthesiologica Scandinavica*, vol. 59, no. 10, pp. 1319-29.

Hallberg, U. & Sverke, M. 2004, 'Construct validity of the Maslach Burnout Inventory: two Swedish health care samples', *European Journal of Psychological Assessment*, vol. 20, no. 4, pp. 320-38.

Halpern, N. 2014, 'Innovative designs for the smart icu: part 2', *CHEST*, vol. 145, no. 3, pp. 646-58.

Halpern, N., Pastores, S., Thaler, H. & Greenstein, R. 2006, 'Changes in critical care beds and occupancy in the United States 1985–2000: differences attributable to hospital size', *Critical Care Medicine*, vol. 34, no. 8, pp. 2105-12.

Halpern, S. 2011, 'ICU capacity strain and the quality and allocation of critical care.', *Current Opinion in Critical Care*, vol. 17, no. 6, pp. 648-57.

Hanane, T., Keegan, M., Seferian, E., Gajic, O. & Afessa, B. 2008, 'The association between nighttime transfer from the intensive care unit and patient outcome', *Critical Care Medicine*, vol. 36, no. 8, pp. 2232-7.

Harding, T. & Wright, M. 2014, 'Unequal staffing: a snapshot of nurse staffing in critical care units in New South Wales, Australia', *Contemporary Nurse*, vol. 47, no. 2, pp. 7-15.

Hariharan, S. & Kumar Dey, P. 2010, 'A comprehensive approach to quality management of intensive care services ', *International Journal of Health Care Quality Assurance*, vol. 23, no. 3, pp. 287-300.

Harris, R., Sims, S., Parr, J. & Davies, N. 2015, 'Impact of 12h shift patterns in nursing: a scoping review', *International Journal of Nursing Studies*, vol. 52, no. 2, pp. 605-34.

Harris, S., Singer, M., Rowan, K. & Sanderson, C. 2015, 'Delay to admission to critical care and mortality among deteriorating ward patients in UK hospitals: a multicentre, prospective, observational cohort study', *The Lancet*, vol. 385, p. S40.

Hart, P. & Davis, N. 2011, 'Effects of Nursing Care and Staff Skill Mix on Patient Outcomes Within Acute Care Nursing Units', *Journal of Nursing Care Quality*, vol. 26, no. 2, pp. 161-8.

Hartmann, C., Meterko, M., Zhao, S., Palmer, J. & Berlowitz, D. 2013, 'Validation of a novel safety climate instrument in VHA nursing homes', *Medical Care Research and Review*, vol. 70, no. 4, pp. 400-17.

Hasibeder, W. 2010, 'Does standardization of critical care work?', *Current opinion in critical care*, vol. 16, no. 5, pp. 493-8.

Hawari, F., Al Najjar, T., Zaru, L., Al Fayoumee, W., Salah, S. & Mukhaimar, M. 2009, 'The effect of implementing high-intensity intensive care unit staffing model on outcome of critically ill oncology patients', *Critical Care Medicine*, vol. 37, no. 6, pp. 1967-71.

Hayes, L., O'Brien-Pallas, L., Duffield, C., Shamian, J., Buchan, J., Hughes, F., Spence Laschinger, H., North, N. & Stone, P. 2006, 'Nurse turnover: a literature review', *International Journal of Nursing Studies*, vol. 43, no. 2, pp. 237-63.

He, M., Tang, A., Ge, X. & Zheng, J. 2016, 'Pressure ulcers in the intensive care unit: an analysis of skin barrier risk factors', *Advances in Skin & Wound Care*, vol. 29, no. 11, pp. 493-8.

Hebden, J. 2015, 'Tackling central line-associated bloodstream infections in the ICU', *Nursing2015 Critical Care*, vol. 10, no. 5, pp. 34-9.

Hendrich, A. & Haydar, Z. 2017, 'Building a high ‐ reliability organization: one system's patient safety journey', *Journal of Healthcare Management*, vol. 62, no. 1, pp. 13-7.

Hewson, K., Burrell, A., Elliott, D., Webb, S., Seppelt, I., Taylor, C. & Glass, P. 2011, 'Compliance with processes of care in intensive care units in Australia and New Zealand – a point prevalence study', *Anaesthesia and Intensive Care* vol. 39, pp. 926-35.

Hickey, P., Gauvreau, K., Connor, J., Sporing, E. & Jenkins, K. 2010, 'The relationship of nurse staffing, skill mix, and Magnet® recognition to institutional volume and mortality for congenital heart surgery', *Journal of Nursing Administration*, vol. 40, no. 5, pp. 226-32.

Higgins, J. & Green, S. 2008, 'Assessing Risk of Bias in Included Studies', in J. Higgins & S. Green (eds), *Cochrane Handbook for Systematic Reviews of Interventions*, 5 edn, A John Wiley & Sons, Ltd., United Kingdom, pp. 188-242.

Higgins, T., Teres, D. & Nathanson, B. 2008, 'Outcome prediction in critical care: the mortality probability models', *Current Opinion in Critical Care*, vol. 15, no. 5, pp. 498-505.

Hines, S., Luna, K., Lofthus, J., Marquardt, M. & Stelmokas, D. 2008, *Becoming a High Reliability Organization: Operational Advice for Hospital Leaders*, Agency for Healthcare Resarch and Quality, U.S. Department of Health and Human Services, Rockvile, MD, AHRQ publication: 08-0022.

Hobson, C. & Bihorac, A. 2015, 'Critical care delivery and ICU structure—the elephant in the room', *Critical Care Medicine*, vol. 43, no. 12, pp. e590-e1.

Holodinsky, J., Hebert, M., Zygun, D., Rigal, R., Berthelot, S., Cook, D. & Stelfox, H. 2015, 'A survey of rounding practices in Canadian adult intensive care units', *PloS one*, vol. 10, no. 12, p. e0145408.

Howell, E., Bessman, E., Marshall, R. & Wright, S. 2010, 'Hospitalist bed management effecting throughput from the emergency department to the intensive care unit', *Journal of Critical Care*, vol. 25, no. 2, pp. 184-9.

Howell, M. 2011, 'Managing ICU throughput and understanding ICU census.', *Current Opinion in Critical Care*, vol. 17, no. 6, pp. 626-33.

Howie, A. & Ridley, S. 2008, 'Bed occupancy and incidence of Methicillin-resistant Staphylococcus aureus infection in an intensive care unit', *Anaesthesia*, vol. 63, no. 10, pp. 1070-3.

Hravnak, M., Schmid, A., Ott, L. & Pinsky, M. 2011, 'Causes of Failure to Rescue', in M.A. DeVita, K. Hillman & R. Bellomo (eds), *Textbook of Rapid Response Systems*, Springer New York, pp. 141-50.

Huang, Y., Huang, J., Tsauo, Y. & Ko, W. 2010, 'Definition, risk factors and outcome of prolonged surgical intensive care unit stay ', *Anaesthesia & Intensive Care*, vol. 38, no. 3, pp. 500-5.

Hultman, C., Tong, W., Surrusco, M., Roden, K., Kiser, M. & Cairns, B. 2012, 'To everything there is a season: impact of seasonal change on admissions, acuity of injury, length of stay, throughput, and charges at an accredited, regional burn center', *Annals of Plastic Surgery*, vol. 69, no. 1, pp. 30-4.

Hung, C., Hsu, S., Lee, L. & Huang, C. 2013, 'The effects of contextual and structural factors on patient safety in nursing units', *Journal of Nursing Research*, vol. 21, no. 3, pp. 225-33.

Hung, S., Kung, C., Hung, C., Liu, B., Liu, J., Chew, G., Chuang, H., Lee, W. & Lee, T. 2014, 'Determining delayed admission to intensive care unit for mechanically ventilated patients in the emergency department', *Critical Care*, vol. 18, no. 4, pp. 485-504.

Hunter, J. 2012, 'Ventilator associated pneumonia', *BMJ*, vol. 344, p. e3325.

Hyzy, R., Flanders, S., Pronovost, P., Berenholtz, S., Watson, S., George, C., Goeschel, C., Maselli, J. & Auerbach, A. 2010, 'Characteristics of intensive care units in Michigan: not an open and closed case', *Journal of Hospital Medicine* vol. 5, no. 1, pp. 4 - 9.

Iapichino, G., Corbella, D., Minelli, C., Mills, G., Artigas, A., Edbooke, D., Pezzi, A., Kesecioglu, J., Patroniti, N., Baras, M. & Sprung, C. 2010, 'Reasons for refusal of admission to intensive care and impact on mortality', *Intensive Care Medicine*, vol. 36, no. 10, pp. 1772-9.

Iapichino, G., Gattinoni, L., Radrizzani, D., Simini, B., Bertolini, G., Ferla, L., Mistraletti, G., Porta, F. & Miranda, D. 2004, 'Volume of activity and occupancy rate in intensive care units: association with mortality', *Intensive Care Medicine*, vol. 30, no. 2, pp. 290-7.

Iapichino, G., Pezza, A., Borotto, E., Mistraletti, G., Meroni, M. & Corbella, D. 2005, 'Performance determinants and flexible icu organisation', *Minerva Anestesiologica* vol. 71, no. 6, pp. 273-80.

Iapichino, G., Radrizzani, D., Rossi, C., Pezzi, A., Anghileri, A., Boffelli, S., Giardino, M., Mistraletti, G. & Bertolini, G. 2007, 'Proposal of a flexible structural-organizing model for the intensive care units', *Minerva Anestesiologica*, vol. 73, no. 10, pp. 501-6.

ICN 2010, *Management of Nursing and Healthcare Services Position Statement*, International Council of Nurses, Geneva, Switzerland.

ICNARC 2015, *Annual Quality Report Adult Critical Care 2013/14*, Intensive Care National Audit and Research Centre, London.

Iliopoulou, K. & While, A. 2010, 'Professional autonomy and job satisfaction: survey of critical care nurses in mainland Greece', *Journal of Advanced Nursing*, vol. 66, no. 11, pp. 2520-31.

Inglis, S., Clark, R., McAlister, F., Ball, J., Lewinter, C., Cullington, D., Stewart, S. & Cleland, J. 2010, 'Structured telephone support or telemonitoring programmes for patients with chronic heart failure', *Journal of Evidence-Based Medicine*, vol. 3, no. 4, pp. 228-.

Ismaeil, M., El-Shahat, H., El-Gammal, M. & Abbas, A. 2013, 'Unplanned versus planned extubation in respiratory intensive care unit, predictors of outcome', *Egyptian Journal of Chest Diseases and Tuberculosis*, vol. 63, no. 1, pp. 219-31.

Iwashyna, T. & Kahn, J. 2014, 'Regionalization of Critical Care', in D. Scales & G. Rubenfeld (eds), *The Organization of Critical Care*, Springer, New York, pp. 217-33.

Iwashyna, T., Kramer, A. & Kahn, J. 2009, 'Intensive care unit occupancy and patient outcomes', *Critical Care Medicine* vol. 37, no. 5, pp. 1545-57.

Jackson, N. & Waters, E. 2005, 'Criteria for the systematic review of health promotion and public health interventions', *Health Promotion International*, vol. 20, no. 4, pp. 367-74.

Jarachovic, M., Mason, M., Kerber, K. & McNett, M. 2011, 'The role of standardized protocols in unplanned extubations in a medical intensive care unit', *American Journal of Critical Care*, vol. 20, no. 4, pp. 304-12.

Johnson, D., Schmidt, U., Bittner, E., Christensen, B., Levi, R. & Pino, R. 2013, 'Delay of transfer from the intensive care unit: a prospective observational study of incidence, causes, and financial impact', *Critical Care*, vol. 17, no. 4, p. R128.

Johnson, V., Mangram, A., Mitchell, C., Lorenzo, M., Howard, D. & Dunn, E. 2009, 'Is there a benefit to multidisciplinary rounds in an open trauma intensive care unit regarding ventilator-associated pneumonia?', *The American Surgeon*, vol. 75, no. 12, pp. 1171-4.

Jones, D., DeVita, M. & Bellomo, R. 2011, 'Rapid-response teams', *New England Journal of Medicine*, vol. 365, no. 2, pp. 139-46.

Jones, D., Drennan, K., Hart, G., Bellomo, R. & Web, S. 2012, 'Rapid response team composition, resourcing and calling criteria in Australia', *Resuscitation*, vol. 83, no. 5, pp. 563-7.

Jones, R. 2010, 'Myths of ideal hospital size', *Medical Journal of Australia*, vol. 193, no. 5, pp. 298-300.

Jöreskog, K. 1967, ''A general approach to confirmatory maximum likelihood factor analysis'', *Research Bulletin Series*, vol. 1967, no. 2, pp. 183-202.

Kahn, J., Goss, C., Heagerty, P., Kramer, A., O'Brien, C. & Rubenfeld, G. 2006, 'Hospital volume and the outcomes of mechanical ventilation', *New England Journal of Medicine*, vol. 355, no. 1, pp. 41-50.

Kahn, J., Ten Have, T. & Iwashyna, T. 2009, 'The relationship between hospital volume and mortality in mechanical ventilation: an instrumental variable analysis', *Health Services Research* vol. 44, no. 3, pp. 862-9.

Kahn, S., Morrison, D., Cohen, J., Emed, J., Tagalakis, V., Roussin, A. & Geerts, W. 2010, 'Interventions for implementation of thromboprophylaxis in hospitalized medical and surgical patients at risk for venous thromboembolism (Protocol)', *Cochrane Database of Systematic Reviews*, no. 1, p. CD008201.

Kalil, A., Metersky, M., Klompas, M., Muscedere, J., Sweeney, D., Palmer, L., Napolitano, L., O'grady, N., Bartlett, J. & Carratalà, J. 2016, 'Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 clinical practice guidelines by the Infectious Diseases Society of America and the American Thoracic Society', *Clinical Infectious Diseases*, vol. 63, no. 5, pp. e61-e111.

Kang, H. 2015, 'Sample size determination for repeated measures design using G Power software', *Anesthesia and Pain Medicine*, vol. 10, no. 1, pp. 6-15.

Kanhere, M., Kanhere, H., Cameron, A. & Maddern, G. 2012, 'Does patient volume affect clinical outcomes in adult intensive care units?', *Intensive Care Medicine*, vol. 38, no. 5, pp. 741-51.

Karanikola, M., Papathanassoglou, E., Kalafati, M., Stathopoulou, H., Mpouzika, M. & Goutsikas, C. 2012, 'Exploration of the association between professional interactions and emotional distress of intensive care unit nursing personnel', *Dimensions of Critical Care Nursing*, vol. 31, no. 1, pp. 37-45.

Kastrup, M., von Dossow, V., Seeling, M., Ahlborn, R., Tamarkin, A., Conroy, P., Boemke, W., Wernecke, K. & Spies, C. 2009, 'Key performance indicators in intensive care medicine: a retrospective matched cohort study', *Journal of International Medical Research*, vol. 37, no. 5, pp. 1267-84.

Katz, J., Lishmanov, A., van Diepen, S., Yu, D., Shen, H., Pauley, E., Bhatia, J., Buntaine, A., Das, A., Dangerfield, C., McLaughlin, B., Stouffer, G. & Kaul, P. 2017, 'Length of stay, mortality, cost, and perceptions of care associated with transition from an open to closed staffing model in the cardiac intensive care unit', *Critical Pathways in Cardiology*, vol. 16, no. 2, pp. 62-70.

Kavanagh, B. & Nurok, M. 2016, 'Standardized intensive care. protocol misalignment and impact misattribution', *American Journal of Respiratory and Critical Care Medicine*, vol. 193, no. 1, pp. 17-22.

Kelleher, A., Moorer, A. & Makic, M. 2012, 'Peer-to-peer nursing rounds and hospital-acquired pressure ulcer prevalence in a surgical intensive care unit: a quality improvement project', *Journal of Wound Ostomy & Continence Nursing*, vol. 39, no. 2, pp. 152-7.

Kelly, F., Fong, K., Hirsch, N. & Nolan, J. 2014, 'Intensive care medicine is 60 years old: the history and future of the intensive care unit', *Clinical Medicine*, vol. 14, no. 4, pp. 376-9.

Kelly, L., McHugh, M. & Aiken, L. 2012, 'Nurse outcomes in Magnet(R) and non-magnet hospitals', *Journal of Nursing Administration*, vol. 42, no. 10, pp. S44-S9.

Kesecioglu, J., Schneider, M., van der Kooi, A. & Bion, J. 2012, 'Structure and function: planning a new ICU to optimize patient care.', *Current Opinion in Critical Care*, vol. 18, no. 6, pp. 688-92.

Kiekkas, P., Aretha, D., Panteli, E., Baltopoulos, G. & Filos, K. 2013, 'Unplanned extubation in critically ill adults: clinical review', *Nursing in Critical Care*, vol. 18, no. 3, pp. 123-34.

Kim, S., Horowitz, I., Young, K. & Buckley, T. 2000, 'Flexible bed allocation and performance in the intensive care unit', *Journal of Operations Management*, vol. 18, no. 4, pp. 427-43.

Kjekshus, L., Bernstrøm, V., Dahl, E. & Lorentzen, T. 2014, 'The effect of hospital mergers on long-term sickness absence among hospital employees: a fixed effects multivariate regression analysis using panel data', *BMC Health Services Research*, vol. 14, no. 50, pp. 1-10.

Kline, R. 2011, *Principles and Practice of Structural Equation Modeling*, 3 edn, Guilford press, New York.

Klompas, M. & Berra, L. 2016, 'Should ventilator-associated events become a quality Indicator for ICUs?', *Respiratory Care*, vol. 61, no. 6, pp. 723-36.

Klompas, M., Kulldorff, M. & Platt, R. 2008, 'Risk of misleading ventilator-associated pneumonia rates with use of standard clinical and microbiological criteria', *Clinical Infectious Diseases*, vol. 46, no. 9, pp. 1443-6.

Klopper, H., Aiken, L. & Coetzee, S. 2012, 'Hospital work environments, nurse burnout and job dissatisfaction: a view in the mirror of international evidence', paper presented to the *Sigma Theta Tau International Biennial Convention (41st)*, Texas USA, viewed 2012-01-11t10:56:10z.

Klopper, H., Coetzee, S., Pretorius, R. & Bester, P. 2012, 'Practice environment, job satisfaction and burnout of critical care nurses in South Africa', *Journal of Nursing Management*, vol. 20, no. 5, pp. 685-95.

Knani, M. & Fournier, P. 2013, 'Burnout, job characteristics, and intent to leave: does work experience have any effect', *Journal of Emerging Trends in Economics and Management Sciences*, vol. 4, no. 4, pp. 403-8.

Knaus, W., Draper, E., Wagner, D. & Zimmerman, J. 1986, 'An evaluation of outcome from intensive care in major medical centers', *Annals of Internal Medicine*, vol. 104, no. 3, pp. 410-8.

Kodadek, L. & Haut, E. 2016, 'Venous Thromboembolism in the Intensive Care Unit', in N. Martin & L. Kaplan (eds), *Principles of Adult Surgical Critical Care*, Springer International Publishing, Baltomie USA, pp. 335-42.

Kong, F., Cook, D., Paterson, D., Whitby, M. & Clements, A. 2011, 'Do staffing and workload levels influence the risk of new meticillin-resistant Staphylococcus aureus acquisitions in a well-resourced intensive care unit?', *Journal of Hospital Infection*, vol. 80, no. 4, pp. 331-9.

Kramer, A., Higgins, T. & Zimmerman, J. 2012, 'Intensive care unit readmissions in U.S. hospitals: Patient characteristics, risk factors, and outcomes', *Critical Care Medicine*, vol. 40, no. 1, pp. 3-10.

Kramer, A., Higgins, T. & Zimmerman, J. 2013, 'The association between ICU readmission rate and patient outcomes', *Critical Care Medicine*, vol. 41, no. 1, pp. 24-33.

Kramer, A. & Zygun, D. 2011, 'Do neurocritical care units save lives? Measuring the impact of specialized ICUs', *Neurocritical Care*, vol. 14, no. 3, pp. 329-33.

Kramer, A. & Zygun, D. 2014, 'Neurocritical care: why does it make a difference?', *Current Opinion in Critical Care*, vol. 20, no. 2, pp. 174-81.

Kramer, M., Schmalenberg, C. & Maguire, P. 2010, 'Nine structures and leadership practices essential for a magnetic (healthy) work environment', *Nursing Administration Quarterly*, vol. 34, no. 1, pp. 4-17.

Kristensen, T., Borritz, M., Villadsen, E. & Christensen, K. 2005, 'The Copenhagen Burnout Inventory: a new tool for the assessment of burnout', *Work & Stress*, vol. 19, no. 3, pp. 192-207.

Kritchevsky, S., Braun, B., Kusek, L., Wong, E., Solomon, S., Parry, M.F., Richards, C. & Simmons, B. 2008, 'The impact of hospital practice on central venous catheter associated bloodstream infection rates at the patient and unit level: a multicenter study', *American Journal of Medical Quality*, vol. 23, no. 1, pp. 24-38.

Kubler, A., Duszynska, W., Rosenthal, V., Fleischer, M., Kaiser, T., Szewczyk, E. & Barteczko-Grajek, B. 2012, 'Device-associated infection rates and extra length of stay in an intensive care unit of a university hospital in Wroclaw, Poland: International Nosocomial Infection Control Consortium's (INICC) findings', *Journal of Critical Care*, vol. 27, no. 1, pp. 105-10.

Kucukarslan, S., Corpus, K., Mehta, N., Mlynarek, M., Peters, M., Stagner, L. & Zimmerman, C. 2013, 'Evaluation of a dedicated pharmacist staffing model in the medical intensive care unit', *Hospital Pharmacy*, vol. 48, no. 11, pp. 922-30.

Kuiper, M. & Girbes, A. 2015, 'The big dilemma: ICU volume-outcome relationships', *Critical Care Medicine*, vol. 43, no. 6, pp. 1338-9.

Kunaviktikul, W., Wichaikhum, O., Nantsupawat, A., Nantsupawat, R., Chontawan, R., Klunklin, A., Roongruangsri, S., Nantachaipan, P., Supamanee, T. & Chitpakdee, B. 2015, 'Nurses' extended work hours: patient, nurse and organizational outcomes', *International Nursing Review*, vol. 62, no. 3, pp. 386-93.

Kyeremanteng, K. & D'Egidio, G. 2015, 'Why process quality measures may be more valuable than outcome measures in critical care patients', *Biology and Medicine*, vol. 7, no. 2, pp. 1-3.

Laerkner, E., Egerod, I. & Hansen, H. 2015, 'Nurses’ experiences of caring for critically ill, non-sedated, mechanically ventilated patients in the intensive care unit: A qualitative study', *Intensive and Critical Care Nursing*, vol. 31, no. 4, pp. 196-204.

Lake, E. 2002, 'Development of the Practice Environment Scale of the Nursing Work Index', *Research in Nursing & Health*, vol. 25, no. 3, pp. 176-88.

Lake, E. 2007, 'The nursing practice environment', *Medical Care Research and Review*, vol. 64, no. 2 suppl, pp. 104S-22S.

Lake, E. & Friese, C. 2006, 'Variations in nursing practice environments: relation to staffing and hospital characteristics', *Nursing Research*, vol. 55, no. 1, pp. 1-9.

Lankshear, A., Sheldon, T. & Maynard, A. 2005, 'Nurse staffing and healthcare outcomes: a systematic review of the international research evidence', *Advances in Nursing Science*, vol. 28, no. 2, pp. 163-74.

Laporta, D., Burns, J. & Doig, C. 2005, 'Bench-to-bedside review: dealing with increased intensive care unit staff turnover: a leadership challenge', *Critical Care*, vol. 9, no. 5, pp. 1-5.

Latif, A., Halim, M. & Pronovost, P. 2015, 'Eliminating Infections in the ICU: CLABSI', *Current Infectious Disease Reports*, vol. 17, no. 7, pp. 1-9.

Laupland, k., Misset, B., Souweine, B., Tabah, A., Azoulay, E., Goldgran, D., Dumenil, A., Vésin, A., Jamali, S., Kallel, H., Clec’h, C., Darmon, M., Schwebel, C. & Timsit, J. 2008 'Mortality associated with timing of admission to and discharge from ICU: a retrospective cohort study', *BMC Health Services Research*, vol. 11, pp. 321-4.

Leblebicioglu, H., Ersoz, G., Rosenthal, V., Yalcin, A., Akan, O., Sirmatel, F., Turgut, H., Ozdemir, D., Alp, E., Uzun, C., Ulusoy, S., Esen, S., Ulger, F., Dilek, A., Yilmaz, H., Kaya, A., Kuyucu, N., Turhan, O., Gunay, N., Gumus, E., Dursun, O., Tulunay, M., Oral, M., Unal, N., Cengiz, M., Yilmaz, L., Sacar, S., Sungurtekin, H., Ugurcan, D., Geyik, M., Sahin, A., Erdogan, S., Aygen, B., Arda, B. & Bacakoglu, F. 2013, 'Impact of a multidimensional infection control approach on catheter-associated urinary tract infection rates in adult intensive care units in 10 cities of Turkey: International Nosocomial Infection Control Consortium findings (INICC)', *American Journal of Infection Control*, vol. 41, no. 10, pp. 885-91.

Lee, H., Chien, T. & Yen, M. 2013, 'Examining factor structure of Maslach Burnout Inventory among nurses in Taiwan', *Journal of Nursing Management*, vol. 21, no. 4, pp. 648-56.

Lee, J., Kim, S., Kim, S., Oh, J., Lee, H., Yum, H., Kim, Y., Hong, S., Park, M., Hwang, S., Yoon, H., Kim, H., Cho, J., Park, S. & Yoo, C. 2014, 'Prevention of venous thromboembolism in medical intensive care unit: a multicenter observational study in Korea', *Journal of Korean Medical Science*, vol. 29, no. 11, pp. 1572-6.

Lee, Y., Stone, P., Pogorzelska-Maziarz, M. & Nembhard, I. 2016, 'Differences in work environment for staff as an explanation for variation in central line bundle compliance in intensive care units', *Health Care Management Review*, vol. Publish Ahead of Print.

Leung, C., Wong, W. & Gomersall, C. 2016, 'Managing intensive care supply-demand imbalance', in J.-L. Vincent (ed.), *Annual Update in Intensive Care and Emergency Medicine 2016*, vol. 2016, Springer International Publishing, Switzerland, pp. 385-92.

Lewis, E., Baernholdt, M., Yan, G. & Guterbock, T. 2014, 'Relationship of adverse events and support to RN burnout', *Journal of Nursing Care Quality*, vol. 30, no. 2, pp. 144-52.

Li, L., Ruan, H. & Yuan, W. 2015, 'The relationship between social support and burnout among ICU Nurses in Shanghai: a cross-sectional study', *Chinese Nursing Research*, vol. 2, no. 3, pp. 45-50.

Li, Y. & Jones, C. 2012, 'A literature review of nursing turnover costs', *Journal of Nursing Management*, vol. 21, no. 3, pp. 405-18.

Lilford, R. & Pronovost, P. 2010, 'Using hospital mortality rates to judge hospital performance: a bad idea that just won't go away', *BMJ Clinical Research*, vol. 340, p. c2016.

Lim, K., Kuo, S., Ko, W., Sheng, W., Chang, Y., Hong, M., Sun, C., Chen, Y. & Chang, S. 2013, 'Efficacy of ventilator-associated pneumonia care bundle for prevention of ventilator-associated pneumonia in the surgical intensive care units of a medical center', *Journal of Microbiology, Immunology and Infection*, vol. 48, no. 3, pp. 316-21.

Lin, F., Chaboyer, W. & Wallis, M. 2009, 'A literature review of organisational, individual and teamwork factors contributing to the ICU discharge process', *Australian Critical Care*, vol. 22, no. 1, pp. 29-43.

Lin, F., Chaboyer, W., Wallis, M. & Miller, A. 2013, 'Factors contributing to the process of intensive care patient discharge: An ethnographic study informed by activity theory', *International Journal of Nursing Studies*, vol. 50, no. 8, pp. 1054-66.

Liou, S. & Cheng, C. 2009, 'Using the Practice Environment Scale of the Nursing Work Index on Asian nurses', *Nursing Research*, vol. 58, no. 3, pp. 218-25.

Lipitz-Snyderman, A., Steinwachs, D., Needham, D., Colantuoni, E., Morlock, L. & Pronovost, P. 2011, 'Impact of a statewide intensive care unit quality improvement initiative on hospital mortality and length of stay: retrospective comparative analysis', *BMJ* vol. 342, pp. 1-7.

Liu, L., Lee, S., Chia, P., Chi, S. & Yin, Y. 2012, 'Exploring the association between nurse workload and nurse-sensitive patient safety outcome indicators', *Journal of Nursing Research*, vol. 20, no. 4, pp. 300-9.

Liu, V., Kipnis, P., Rizk, N. & Escobar, G. 2012, 'Adverse outcomes associated with delayed intensive care unit transfers in an integrated healthcare system', *Journal of Hospital Medicine* vol. 7, no. 3, pp. 224-30.

Loan, L., Patrician, P. & McCarthy, M. 2011, 'Participation in a National Nursing Outcomes Database: monitoring outcomes over time', *Nursing Administration Quarterly*, vol. 35, no. 1, pp. 72-81.

Lobo, V., Ploeg, J., Fisher, A., Peachey, G. & Akhtar-Danesh, N. 2017, 'Critical care nurses' perceptions of the outcomes of working overtime in Canada', *Nursing Outlook*, vol. In press.

Luft, H., Bunker, J. & Enthoven, A. 1979, 'Should operations be regionalized?', *New England Journal of Medicine*, vol. 301, no. 25, pp. 1364-9.

Lyndon, A. 2016, *Burnout Among Health Professionals and its Effect on Patient Safety*, Agency for Healthcare Research and Quality, Maryland, United States

Mallor, F., Azcárate, C. & Barado, J. 2015, 'Optimal control of ICU patient discharge: from theory to implementation', *Health Care Management Science*, vol. 18, no. 3, pp. 234-50.

Mann, C. 2003, 'Observational research methods. Research design II: cohort, cross sectional, and case-control studies', *Emergency Medicine Journal*, vol. 20, no. 1, pp. 54-60.

Manojlovich, M., Antonakos, C. & Ronis, D. 2009, 'Intensive care units, communication between nurses and physicians, and patient outcomes', *American Journal of Critical Care*, vol. 18, no. 1, pp. 21-30.

Manojlovich, M., Antonakos, C. & Ronis, D. 2010, 'The relationship between hospital size and ICU type on select adverse patient outcomes', *Hospital Topics*, vol. 88, no. 2, pp. 33-42.

Marsteller, J., Sexton, J., Hsu, Y., Hsiao, C., Holzmueller, C., Pronovost, P. & Thompson, D. 2012, 'A multicenter, phased, cluster-randomized controlled trial to reduce central line-associated bloodstream infections in intensive care units', *Critical Care Medicine*, vol. 40, no. 11, pp. 2933-9.

Martinez, E., Donelan, K., Henneman, J., Berenholtz, S., Miralles, P., Krug, A., Iezzoni, L., Charnin, J. & Pronovost, P. 2014, 'Identifying meaningful outcome measures for the intensive care unit', *American Journal of Medical Quality*, vol. 29, no. 2, pp. 144-52.

Mascia, D., Morandi, F. & Cicchetti, A. 2014, 'Hospital restructuring and physician job satisfaction: an empirical study', *Health Policy*, vol. 114, no. 2, pp. 118-27.

Maslach, C. 1982, *Burnout: The High Cost of Caring*, Prentice Hall, Englewood Cliffs, NJ, California.

Maslach, C. & Jackson, S. 1981a, 'The measurement of experienced burnout', *Journal of Occupational Behaviour*, vol. 2, no. 2, pp. 99-113.

Maslach, C. & Jackson, S. 1981b, 'The measurement of experienced burnout', *Journal of Organizational Behavior*, vol. 2, no. 2, pp. 99-113.

Maslach, C., Jackson, S. & Leiter, M. 1996a, *Maslach Burnout Inventory Manual*, 3 edn, Consulting Psychologists Press, Mountain View, California.

Maslach, C., Jackson, S.E. & Leiter, M. 1996b, *Maslach Burnout Inventory: Manual*, Consulting Psychologist Press, Palo Alto, CA.

Masson, S., Mabasa, V., Malyuk, D. & Perrott, J. 2013, 'Validity evidence for FASTHUG-MAIDENS, a mnemonic for identifying drug-related problems in the intensive care unit', *Canadian Journal of Hospital Pharmacy*, vol. 66, no. 3, pp. 157-62.

Mathioudakis, N. & Golden, S. 2015, 'A comparison of inpatient glucose management guidelines: implications for patient safety and quality', *Current Diabetes Reports*, vol. 15, no. 3, pp. 1-11.

Matlakala, M. 2015, 'The views of intensive care nurses regarding short-term deployment : original research', *Curationis*, vol. 38, no. 1, pp. 1-5.

Matlakala, M., Bezuidenhout, M. & Botha, A. 2014a, 'Challenges encountered by critical care unit managers in the large intensive care units', *Curationis*, vol. 37, no. 1, pp. 1-7.

Matlakala, M., Bezuidenhout, M. & Botha, A. 2014b, 'Strategies to address management challenges in larger intensive care units', *Journal of Nursing Management*, vol. 23, no. 7, pp. 945-53.

McAdam, J. & Puntillo, K. 2015, 'The Intensive Care Unit', in B. Ferrell (ed.), *Structure and Processes of Care*, vol. 1, Oxford University Press, New York.

Mclaws, M. & Burrell, A. 2011, 'Reducing central line associated bacteraemia in intensive care units using low cost strategies', *BMC Proceedings*, vol. 5, no. Suppl 6, p. P58.

McNelis, J., Schwall, G. & Collins, J. 2012, 'Robotic remote presence technology in the surgical intensive care unit', *Journal of Trauma and Acute Care Surgery*, vol. 72, no. 2, pp. 527-30.

Meadows, C., Rattenberry, W. & Waldmann, C. 2011, 'Centralisation of specialist critical care services', *Journal of the Intensive Care Society*, vol. 12, no. 2, pp. 87-9.

Mealer, M. 2016, 'Burnout syndrome in the intensive care unit: future directions for research', *Annals of the American Thoracic Society*, vol. 13, no. 7, pp. 997-8.

Meeusen, V., Van Dam, K., Brown-Mahoney, C., Van Zundert, A. & Knape, H. 2011, 'Understanding nurse anesthetists' intention to leave their job: how burnout and job satisfaction mediate the impact of personality and workplace characteristics', *Health Care Management Review*, vol. 36, no. 2, pp. 155-63.

Meyer, R., Wang, S., Li, X., Thomson, D. & O'Brien-Pallas, L. 2009, 'Evaluation of a patient care delivery model: patient outcomes in acute cardiac care', *Journal of Nursing Scholarship*, vol. 41, no. 4, pp. 399-410.

Meynaar, I., van Saase, J., Feberwee, T., Aerts, T., Bakker, J. & Thijsse, W. 2015, 'Burnout among Dutch intensivists', *Intensive Care Medicine Experimental*, vol. 3, no. Suppl 1, p. A140.

Middleton, S., Griffiths, R., Fernandez, R. & Smith, B. 2008, 'Nursing practice environment: How does one Australian hospital compare with magnet hospitals?', *International Journal of Nursing Practice*, vol. 14, no. 5, pp. 366-72.

Miele, C. & Checkley, W. 2016, 'Defining ICU structure and process: working toward a worldwide agenda', *Critical Care Medicine*, vol. 44, no. 10, pp. 1952-3.

Miller, J. 2006, *Critical Review of Quantitative Research*, Northern Health, British Columbia.

Minvielle, M., Aegerter, P., Dervaux, B., Boumendil, A., Retbif, A., Jars-Guincestre, M., Guidet, B. & Tenaillon, A. 2005, 'Culture, organization, and management in intensive care: construction and validation of a multidimensional questionnaire', *Journal of Critical Care*, vol. 20, no. 2, pp. 126-38.

Miranda, D., Nap, R., de Rijk, A., Schaufeli, W. & Iapichino, G. 2003, 'Nursing activities score', *Critical Care Medicine*, vol. 31, no. 2, pp. 374-82.

Mitchell, A., Schatz, M. & Francis, H. 2014, 'Designing a critical care nurse–led rapid response team using only available resources: 6 years later', *Critical Care Nurse*, vol. 34, no. 3, pp. 41-56.

Moher, D., Liberati, J., Tetzlaff, A. & Altman, D. 2009, 'Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement ', *Physical Therapy*, vol. 89, no. 9, pp. 873-80.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P. & Stewart, L. 2015, 'Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement', *Systematic Reviews*, vol. 4, no. 1, pp. 1-9.

Mokhtari, M., Attarian, H., Norouzi, M., Kouchek, M., Kashani, B., Sirati, F., Pourmirza, B. & Mir, E. 2014, 'Venous thromboembolism risk assessment, prophylaxis practices and interventions for its improvement (AVAIL-ME Extension Project, Iran)', *Thrombosis Research*, vol. 133, no. 4, pp. 567-73.

Momennasab, M., Karimi, F., Dehghanrad, F. & Zarshenas, L. 2017, 'Evaluation of nursing workload and efficiency of staff allocation in a trauma intensive care unit', *Trauma Monthly*, no. In Press, p. e58161.

Moneke, M. & Ogwo, J. 2014, 'How organizational commitment of critical care nurses influence their overall job satisfaction', *Journal of Nursing Education and Practice*, vol. 4, no. 1, pp. 148-61.

Moneke, N. & Umeh, O. 2013, 'Factors influencing critical care nurses' perception of their overall job satisfaction: an empirical study', *Journal of Nursing Administration*, vol. 43, no. 4, pp. 201-7.

Moneke, N. & Umeh, O. 2014, 'Leadership practices influence job satisfaction', *Nursing Critical Care*, vol. 9, no. 2, pp. 33-6.

Moreno Arroyo, M., Jerez González, J., Cabrera Jaime, S., Estrada Masllorens, J. & López Martín, A. 2013, 'Seven hour shifts versus 12 hours in intensive nursing care: going against the tide', *Enfermeria Intensiva* vol. 24, no. 3, pp. 98-103.

Moreno, R., Bauer, P. & Metnitz, P. 2010, 'Characterizing performance profiles of ICUs', *Current Opinion in Critical Care*, vol. 16, no. 5, pp. 477-81.

Moreno, R., Rhodes, A. & Donchin, Y. 2009, 'Patient safety in intensive care medicine: the Declaration of Vienna', *Intensive Care Medicine*, vol. 35, no. 10, pp. 1667-72.

Morris, A., Forrest, R. & Campbell, A. 2010, 'Thromboprophylaxis in intensive care: a nationwide, multidisciplinary quality improvement project', *Journal of the Intensive Care Society*, vol. 11, no. 3, pp. 174-8.

Mosallam, R., Hamidi, S. & Elrefaay, M. 2015, 'Turnover intention among intensive care unit nurses in Alexandria, Egypt', *Journal Of The Egyptian Public Health Association*, vol. 90, no. 2, pp. 46-51.

Moss, M., Good, V., Gozal, D., Kleinpell, R. & Sessler, C. 2016a, 'A critical care societies collaborative statement: burnout syndrome in critical care health-care professionals, a call for action', *American Journal of Respiratory and Critical Care Medicine*, vol. 194, no. 1, pp. 106-13.

Moss, M., Good, V., Gozal, D., Kleinpell, R. & Sessler, C. 2016b, 'An official critical care societies collaborative statement: burnout syndrome in critical care healthcare professionals: a call for action', *Critical Care Medicine*, vol. 44, no. 7, pp. 1414-21.

Mullarkey, M., Duffy, A. & Timmins, F. 2011, 'Trust between nursing management and staff in critical care: a literature review', *Nursing in Critical Care*, vol. 16, no. 2, pp. 85-91.

Murphy, D., Ogbu, O. & Coopersmith, C. 2015, 'Icu director data: using data to assess value, inform local change, and relate to the external world', *CHEST*, vol. 147, no. 4, pp. 1168-78.

Murthy, S. & Wunsch, H. 2012, 'Clinical review: international comparisons in critical care - lessons learned', *Critical Care* vol. 16, no. 2, pp. 218-25.

Myhren, H., Ekeberg, O. & Stokland, O. 2013, 'Job Satisfaction and burnout among intensive care unit nurses and physicians', *Critical Care Research and Practice*, vol. 2013, pp. 1-6.

Naser, W., Schwartz, N., Finkelstein, R. & Bisharat, N. 2016, 'Outcome of mechanically ventilated patients initially denied admission to an intensive care unit and subsequently admitted', *European Journal of Internal Medicine*, vol. 35, pp. 100-5.

Nates, J., Nunnally, M., Kleinpell, R., Blosser, S., Goldner, J., Birriel, B., Fowler, C., Byrum, D., Miles, W., Bailey, H. & Sprung, C. 2016, 'ICU admission, discharge, and triage guidelines: a framework to enhance clinical operations, development of institutional policies, and further research', *Critical Care Medicine*, vol. 44, no. 8, pp. 1553-602.

Neamatollahi, R. & Jalali, R. 2015, 'The Relationship between Organizational Commitment and Burnout among Nurses in Intensive Care Units', *Int. J. Rev. Life. Sci.*, vol. 5, no. 9, pp. 253-8.

Neff, D., Cimiotti, J., Heusinger, A. & Aiken, L. 2011, 'Nurse reports from the frontlines: analysis of a statewide nurse survey', *Nursing Forum*, vol. 46, no. 1, pp. 4-10.

Neuraz, A., Guérin, C., Payet, C., Polazzi, S., Aubrun, F., Dailler, F., Lehot, J., Piriou, V., Neidecker, J., Rimmelé, T., Schott, A. & Duclos, A. 2015, 'Patient mortality is associated with staff resources and workload in the ICU: a multicenter observational study', *Critical Care Medicine*, vol. 43, no. 8, pp. 1587-94.

Nguyen, Y. & Milbrandt, E. 2009, 'Are specialized ICUs so special?', *Critical Care*, vol. 13, no. 5, pp. 314-15.

Nguyen, Y., Wallace, D., Yordanov, Y., Trinquart, L., Blomkwist, J., Angus, D., Kahn, J., Ravaud, P. & Guidet, B. 2015, 'The volume-outcome relationship in critical care: a systematic review and meta-analysis', *CHEST*, vol. 148, no. 1, pp. 79-92.

Nguyen, Y., Wunsch, H. & Angus, D. 2010a, 'Critical care: the impact of organization and management on outcomes', *Current Opinion in Critical Care*, vol. 16, no. 5, pp. 487-92.

Nguyen, Y., Wunsch, H. & Angus, D.C. 2010b, 'Critical care: the impact of organization and management on outcomes', *Curr Opin Crit Care*, vol. 16, no. 5, pp. 487-92.

NHMRC 2007, *National Statement on Ethical Conduct in Human Research*, Canberra, Australia, pp. 1-109.

NHMRC 2014, *Levels of Evidence and Grades for Recommendations for Developers of Guidelines*, National Health and Medical Research Council, Canberra, Australia.

Niedner, M., Muething, S. & Sutcliffe, K. 2013, 'The high-reliability pediatric intensive care unit', *Pediatric Clinics*, vol. 60, no. 3, pp. 563-80.

Nilsson, L., Pihl, A., TÅGsjÖ, M. & Ericsson, E. 2012, 'Adverse events are common on the intensive care unit: results from a structured record review', *Acta Anaesthesiologica Scandinavica*, vol. 56, no. 8, pp. 959-65.

Norris, B., Currie, L. & Lecko, C. 2012, 'The importance of applying human factors to nursing practice', *Nursing Standard*, vol. 26, no. 32, pp. 36-40.

Nosrati, H., Clay-Williams, R., Cunningham, F., Hillman, K. & Braithwaite, J. 2013, 'The role of organisational and cultural factors in the implementation of system-wide interventions in acute hospitals to improve patient outcomes: protocol for a systematic literature review', *BMJ Open*, vol. 3, no. 3, p. e002268.

NSW Health 2010a, *Health Infomation Exchange* NSW Health Department Sydney, Australia.

NSW Health 2010b, *Health Policy Analysis, Acute Inpatient Projections: Final Report 2010*, NSW Health Department, Sydney, Australia.

NSW Health 2017, 'NSW Health Budget 2016-17', NSW Ministry of Health,, Sydney, Australia.

Nulty, D. 2008, 'The adequacy of response rates to online and paper surveys: what can be done?', *Assessment & Evaluation in Higher Education*, vol. 33, no. 3, pp. 301-14.

O'Brien-Pallas, L., Irvine, D., Peereboom, E. & Murray, M. 1997, 'Measuring nursing workload: understanding the variability', *Nursing Economics*, vol. 15, no. 4, pp. 171-82.

O'Meara, L. & Nagarsheth, K. 2015, 'Pressure Ulcer, Complication of Care in ICU', in P. Papadakos & M. Gestring (eds), *Encyclopedia of Trauma Care*, Springer, Berlin, Germany, pp. 1300-20.

Okuda, N., Tsunano, Y., Kohata, H., Nakataki, E., Itagaki, T., Onodera, M., Imanaka, H. & Nishimura, M. 2014, 'Delayed discharge from the intensive care unit', *The Japanese Journal of Anesthesiology*, vol. 63, no. 10, pp. 1164-6.

Olausson, S., Ekebergh, M. & Österberg, S. 2014, 'Nurses' lived experiences of intensive care unit bed spaces as a place of care: a phenomenological study', *Nursing in Critical Care*, vol. 19, no. 3, pp. 126-34.

Olds, D., Aiken, L., Cimiotti, J. & Lake, E. 2017, 'Association of nurse work environment and safety climate on patient mortality: a cross-sectional study', *International Journal of Nursing Studies*, vol. 74, pp. 155-61.

Ontario Health 2010, *Framework for Public Reporting on Health Work Environments in Ontario Healthcare Settings*, Ontario Ministry of Health Quality Council, Toronto.

Ouanes, I., Schwebel, C., Francais, A., Bruel, C., Philippart, F., Vesin, A., Soufir, L., Adrie, C., Garrouste-Orgeas, M., Timsit, J. & Misset, B. 2012, 'A model to predict short-term death or readmission after intensive care unit discharge', *Journal of Critical Care*, vol. 27, no. 4, pp. 422-8.

Pacheco, E., Campos, I., Seixas, J., Conejo, S., Vieira, H., Mazutti, S., Garcia, C. & Noritomi, D. 2011, 'Daily multidisciplinary rounds reduce ICU length of stay', *Critical Care*, vol. 15, no. Suppl 2, pp. 1-31.

Padgett, J., Gossett, K., Mayer, R., Chien, W. & Turner, F. 2017, 'Improving patient safety through high reliability organizations', *The Qualitative Report*, vol. 22, no. 2, pp. 410-25.

Padilha, K., de Sousa, R., Garcia, P., Bento, S., Finardi, E. & Hatarashi, R. 2010, 'Nursing workload and staff allocation in an intensive care unit: a pilot study according to Nursing Activities Score (NAS)', *Intensive and Critical Care Nursing*, vol. 26, no. 2, pp. 108-13.

Padilha, K., de Sousa, R., Queijo, A., Mendes, A. & Reis Miranda, D. 2008, 'Nursing Activities Score in the intensive care unit: analysis of the related factors', *Intensive and Critical Care Nursing*, vol. 24, no. 3, pp. 197-204.

Paiva, J. 2015, 'ICU organization: the song, the singers, and the way the singers sing', *Critical Care Medicine*, vol. 43, no. 3, pp. 695-6.

Pallant, J. 2013, *SPSS Survival Manual*, Allen and Unwin, London.

Palomar, M., Álvarez-Lerma, F., Riera, A., Díaz, M., Torres, F., Agra, Y., Larizgoitia, I., Goeschel, C. & Pronovost, P. 2013, 'Impact of a national multimodal intervention to prevent catheter-related bloodstream infection in the ICU: the Spanish experience', *Critical Care Medicine*, vol. 41, no. 10, pp. 2364-72.

Papathanassoglou, E., Karanikola, M., Kalafati, M., Giannakopoulou, M., Lemonidou, C. & Albarran, J. 2012, 'Professional autonomy, collaboration with physicians, and moral distress among European intensive care nurses', *American Journal of Critical Care*, vol. 21, no. 2, pp. 41-52.

Parikh, A., Huang, S., Murthy, P., Dombrovskiy, V., Nolledo, M., Lefton, R. & Scardella, A. 2012, 'Quality improvement and cost savings after implementation of the Leapfrog intensive care unit physician staffing standard at a community teaching hospital', *Critical Care Medicine*, vol. 40, no. 10, pp. 2754-9.

Parikha, k., Ohb, D., Sittipuntc, C., Kalimd, H., Ullahe, S. & Aggarwalf, S. 2012, 'Venous thromboembolism prophylaxis in medical ICU patients in Asia (VOICE Asia): A multicenter, observational, cross-sectional study', *Thrombosis Research*, vol. 129, no. 4, pp. 152-8.

Park, S., In, Y., Suh, G., Sohn, K. & Kim, E. 2013, 'Evaluation of adverse drug reactions in medical intensive care units', *European Journal of Clinical Pharmacology*, vol. 69, no. 1, pp. 119-31.

Parker, D., Tuckett, A., Eley, R. & Hegney, D. 2010, 'Construct validity and reliability of the Practice Environment Scale of the Nursing Work Index for Queensland nurses', *International Journal of Nursing Practice*, vol. 16, no. 4, pp. 352-8.

Parker, M. 2016, 'Teamwork in the ICU–do we practice what we preach?', *Critical Care Medicine*, vol. 44, no. 2, pp. 254-5.

Parmeshwar, K., Vishwanathan, J. & Kumar, G. 2015, 'Does a single specialty intensive care unit make better business sense than a multi-specialty intensive care unit? A costing study in a trauma center in India', *Saudi Journal of Anaesthesia*, vol. 9, no. 2, pp. 189-94.

Parry, G. & Power, M. 2015, 'To RCT or not to RCT? The ongoing saga of randomised trials in quality improvement', *BMJ Quality & Safety*, vol. 24, no. 11, pp. 221-3.

Pastores, S. 2015, 'Staffing ratios and workload in critically ill patients: do they impact outcomes?', *Critical Care Medicine*, vol. 43, no. 8, pp. 1775-6.

Pastores, S., Halpern, N., Oropello, J., Kostelecky, N. & Kvetan, V. 2015, 'Critical care organizations in academic medical centers in North America: a descriptive report', *Critical Care Medicine*, vol. 43, no. 10, pp. 2239-44.

Patel, V., Kaufman, D. & Cohen, T. 2014, 'Complexity and Errors in Critical Care', in V. Patel, D. Kaufman & T. Cohen (eds), *Cognitive Informatics in Health and Biomedicine*, Springer London, pp. 1-13.

Pati, D., Harvey, T. & Cason, C. 2008, 'Inpatient unit Flexibility: design characteristics', *Environment and Behavior*, vol. 40, no. 2, pp. 205-32.

Patman, S., Dennis, D. & Hill, K. 2011, 'The incidence of falls in intensive care survivors', *Australian Critical Care*, vol. 24, no. 3, pp. 167-74.

Patri, R. & Suresh, M. 2017, 'Modelling the enablers of agile performance in healthcare organization: a TISM approach', *Global Journal of Flexible Systems Management*, vol. 18, no. 3, pp. 251-72.

Peelen, L., de Keizer, N., Peek, N., Scheffer, G., van der Voort, P. & de Jonge, E. 2007, 'The influence of volume and intensive care unit organization on hospital mortality in patients admitted with severe sepsis: a retrospective multicentre cohort study', *Critical Care*, vol. 11, no. 2, pp. R40 1-10.

Peirce, C., James, W., Lewis, I., Dewey, J. & Mead, G. 1982, *Pragmatism, The Classic Writings*, Hackett Publishing Company, Indianapolis.

Peltonen, L., McCallum, L., Siirala, E., Haataja, M., Laine, H., Salanter, S. & Lin, F. 2015, 'An integrative literature review of organisational factors associated with admission and discharge delays in critical care', *BioMed Research International*, no. 868653, pp. 1-12.

Penner, R., Brindley, P. & Jacka, M. 2005, 'Best evidence in critical care medicine: stress ulcer prophylaxis in the intensive care unit: damned if you do, damned if you don't', *Canadian Journal of Anaesthesia*, vol. 52, no. 6, pp. 650-1.

Penning, S., Pretty, C., Preiser, J., Shaw, G., Chase, G. & Desaive, T. 2014, 'Glucose control positively influences patient outcome: a retrospective study', *Journal of Critical Care*, vol. 30, no. 3, pp. 455-9.

Penoyer, D. 2010, 'Nurse staffing and patient outcomes in critical care: a concise review', *Critical Care Medicine*, vol. 38, no. 7, pp. 1521-8.

Peñuelas, Ó., Frutos-Vivar, F. & Esteban, A. 2011, 'Unplanned extubation in the ICU: a marker of quality assurance of mechanical ventilation', *Critical Care*, vol. 15, no. 2, pp. 1-2.

Pereira, S. & Leslie, G. 2009, 'Hypothesis testing', *Australian Critical Care*, vol. 22, no. 4, pp. 187-91.

Perneger, T. 1998, ''What's wrong with Bonferroni adjustments'', *British Medical Journal*, vol. 316, no. 7139, pp. 1236-38.

Phillips, P., Poku, E., Essat, M., Woods, H., Goka, E., Kaltenthaler, E., Walters, S., Shackley, P. & Michaels, J. 2017, 'Procedure volume and the association with short-term mortality following abdominal aortic aneurysm repair in european populations: a systematic review', *European Journal of Vascular and Endovascular Surgery*, vol. 53, no. 1, pp. 77-88.

Pilcher, D., Duke, G., George, C., Bailey, M. & Hart, G. 2007, 'After-hours discharge from intensive care increases the risk of readmission and death', *Anaesthesia and Intensive Care*, vol. 35, no. 4, pp. 477-85.

Pilcher, D., Hoffman, T., Thomas, C., Ernest, D. & Hart, G. 2010, 'Risk-adjusted continuous outcome monitoring with an EWMA chart: could it have detected excess mortality among intensive care patients at Bundaberg Base Hospital?', *Critical Care and Resuscitation*, vol. 12, no. 1, pp. 36-41.

Piña, I., Cohen, P., Larson, D., Marion, L., Sills, M., Solberg, L. & Zerzan, J. 2014, 'A framework for describing health care delivery organizations and systems', *American Journal of Public Health*, vol. 105, no. 4, pp. 670-9.

Pisanti, R., Lombardo, C., Lucidi, F., Violani, C. & Lazzari, D. 2013, 'Psychometric properties of the Maslach Burnout Inventory for Human Services among Italian nurses: a test of alternative models', *Journal of Advanced Nursing*, vol. 69, no. 3, pp. 697-707.

Plummer, M., Blaser, A. & Deane, A. 2014, 'Stress ulceration: prevalence, pathology and association with adverse outcomes', *Critical Care*, vol. 18, no. 2, pp. 213-30.

Poghosyan, L., Aiken, L. & Sloane, D. 2009, 'Factor structure of the Maslach Burnout Inventory: An analysis of data from large scale cross-sectional surveys of nurses from eight countries', *International Journal of Nursing Studies*, vol. 46, no. 7, pp. 894-902.

Polgar, S. & Thomas, S. 2013, *Introduction to Research in the Health Sciences*, Elsevier Health Sciences, Philadelphia, United States.

Preacher, K. 2002, 'Calculation for the test of the difference between two independent correlation coefficients [Computer software]', Vanderbilt University, viewed 8 December 2015.

Pretorius, R. & Klopper, H. 2011, 'Positive practice environments in critical care units in South Africa', *International Nursing Review*, vol. 59, no. 1, pp. 66-72.

Pronovost, P., Angus, D., Dorman, T., Robinson, K., Dremsizov, T. & Young, T. 2002, 'Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review', *JAMA*, vol. 288, no. 17, pp. 2151 - 62.

Pronovost, P., Berenholtz, S., Goeschel, C., Thom, I., Watson, S., Holzmueller, C., Lyon, J., Lubomski, L., Thompson, D., Needham, D., Hyzy, R., Welsh, R., Roth, G., Bander, J., Morlock, L. & Sexton, J. 2008, 'Improving patient safety in intensive care units in Michigan', *Journal of Critical Care*, vol. 23, no. 2, pp. 207-21.

Pronovost, P., Jenckes, M.W., Dorman, T., Garrett, E., Breslow, M., Rosenfeld, B.A., Lipsett, P.A. & Bass, E. 1999, 'Organizational Characteristics of Intensive Care Units Related to Outcomes of Abdominal Aortic Surgery', *JAMA*, vol. 281, no. 14, pp. 1310-7.

Pronovost, P., Watson, S., Goeschel, C., Hyzy, R. & Berenholtz, S. 2016, 'Sustaining reductions in central line–associated bloodstream infections in Michigan intensive care units: a 10-year analysis', *American Journal of Medical Quality*, vol. 31, no. 3, pp. 197-202.

Pryce, C. 2016, 'Impact of shift work on critical care nurses', *Canadian Journal of Critical Care Nursing*, vol. 27, no. 4, pp. 17-21.

Purdy, N., Spence Laschinger, H., Finegan, J., Kerr, M. & Olivera, F. 2010, 'Effects of work environments on nurse and patient outcomes', *Journal of Nursing Management*, vol. 18, no. 8, pp. 901-13.

Quenot, J., Thiery, N. & Barbar, S. 2009, 'When should stress ulcer prophylaxis be used in the ICU?', *Current Opinion in Critical Care*, vol. 15, no. 2, pp. 139-43.

Rafferty, A., Maben, J., West, E. & Robinson, D. 2005, 'What makes a good employer?', *The Global Workforce Initiative, International Council of Nurses*, viewed 14 July 2012, <http//:researchonline.lshtm.ac.uk/id/eprint/7648>.

Rashid, M. 2006, 'A decade of adult intensive care unit design: A study of the physical design features of the best-practice examples', *Critical Care Nursing Quarterly*, vol. 29, no. 4, pp. 282-311.

Rashid, M. 2011, 'Technology and the future of intensive care unit design', *Critical Care Nursing Quarterly*, vol. 34, no. 4, pp. 332-60.

Rashid, M. 2014a, 'Space Allocation in the Award-Winning Adult ICUs of the Last Two Decades (1993-2012): An Exploratory Study', *HERD*, vol. 7, no. 2, pp. 29-56.

Rashid, M. 2014b, 'Two decades (1993-2012) of adult intensive care unit design: a comparative study of the physical design features of the best practice examples', *Critical Care Nursing Quarterly*, vol. 37, no. 1, pp. 3-32.

Rashid, M., Boyle, D. & Crosser, M. 2014, 'Developing nurse and physician questionnaires to assess primary work areas in intensive care units', *Critical Care Nursing Quarterly*, vol. 37, no. 3, pp. 317-35

Raurell Torreda, M. 2011, 'Impact of nursing care on the incidence of invasive mechanical ventilation associated pneumonia', *Enferm Intensiva*, vol. 22, no. 1, pp. 31-8.

Ravitz, A. & Pronovost, P. 2015, 'A model for the intensive care unit as a high reliability organisation', *Edorium Journal of Intensive Care*, vol. 14, no. 1, pp. 1-3.

Reddy, A. & Guzman, J. 2015, 'Quality improvement process in a large intensive care unit: structure and outcomes', *American Journal of Medical Quality*, vol. 31, no. 6, pp. 552-8.

Reddy, A., Pappas, R., Suri, S., Whinney, C., Yerian, L. & Guzman, J. 2015, 'Impact of throughput optimization on intensive care unit occupancy', *American Journal of Medical Quality*, vol. 30, no. 4, pp. 317-22.

Regan, S., Laschinger, H. & Wong, C. 2016, 'The influence of empowerment, authentic leadership, and professional practice environments on nurses' perceived interprofessional collaboration', *Journal of Nursing Management*, vol. 24, no. 1, pp. E54-E61.

Regli, B. & Takala, J. 2006a, 'Intensive Care Medicine in 10 Years', *Update in Intensive Care and Emergency Medicine*, Springer, Switzerland, pp. 1 -18.

Regli, B. & Takala, J. 2006b, 'The Patient Process as the Basis for the Design of an ICU', in M. Fink, P. Suter & W. Sibbald (eds), *Intensive Care Medicine in 10 Years*, Springer Berlin, Germany, pp. 115-32.

Render, M., Freyberg, R., Hasselbeck, R., Hofer, T., Sales, A., Deddens, J., Levesque, O. & Almenoff, P. 2011, 'Infrastructure for quality transformation: measurement and reporting in Veterans administration intensive care units', *BMJ Quality & Safety*, vol. 20, no. 6, pp. 498-507.

Renton, J., Pilcher, D., Santamaria, J., Stow, P., Bailey, M., Hart, G. & Duke, G. 2011, 'Factors associated with increased risk of readmission to intensive care in Australia', *Intensive Care Medicine*, vol. 37, no. 11, pp. 1800-8.

Restrepo, P., Jameson, D. & Carroll, D. 2015, 'Improving deep vein thrombosis prophylaxis with mechanical modalities in surgical intensive care unit', *Journal of nursing care quality*, vol. 30, no. 1, pp. 31-7.

Rhodes, A., Moreno, R. & Chiche, J. 2011, 'ICU structures and organization: putting together all the pieces of a very complex puzzle', *Intensive Care Medicine*, vol. 37, no. 10, pp. 1569-71.

Richardson, J. & Tjoelker, R. 2012, 'Beyond the central line–associated bloodstream infection bundle: the value of the clinical nurse specialist in continuing evidence-based practice changes', *Clinical Nurse Specialist*, vol. 26, no. 4, pp. 205-11.

Riley, W., Davis, S., Miller, K. & McCullough, M. 2010, 'A model for developing high-reliability teams', *Journal of Nursing Management*, vol. 18, no. 5, pp. 556-63.

Rischbieth, A. 2006, 'Matching nurse skill with patient acuity in the intensive care units: a risk management mandate', *Journal of Nursing Management*, vol. 14, no. 5, pp. 397-404.

Ritter, D. 2011, 'The relationship between healthy work environments and retention of nurses in a hospital setting', *Journal of Nursing Management*, vol. 19, no. 1, pp. 27-32.

Robert, R., Reignier, J., Tournoux-Facon, C., Boulain, T., Lesieur, O., Gissot, V., Souday, V., Hamrouni, M., Chapon, C. & Gouello, J. 2012, 'Refusal of intensive care unit admission due to a full unit: impact on mortality', *American Journal of Respiratory and Critical Care Medicine*, vol. 185, no. 10, pp. 1081-7.

Roberts, D., Clark, H. & Rock, B. 2013, 'Development and implementation of a regional intensive care health service model', *Leadership in Health Services*, vol. 26, no. 3, pp. 232-6.

Roberts, K. 1990, 'Some characteristics of one type of high reliability organization', *Organization Science*, vol. 1, no. 2, pp. 160-76.

Robnett, M. 2006, 'Critical care nursing: workforce issues and potential solutions', *Critical Care Medicine*, vol. 34, no. 3, pp. S25-S31.

Roche, M. & Duffield, C. 2010, 'A comparison of the nursing practice environment in mental health and medical-surgical settings', *Journal of Nursing Scholarship*, vol. 42, no. 2, pp. 195-206.

Roche, M., Duffield, C., Frew, B. & Dimitrelis, S. 2015, 'Leadership skills for nursing unit managers to decrease intention to leave', *Nursing Research and Reviews*, vol. 5, pp. 57-64.

Roche, M., Laschinger, H., Spence, K. & Duffield, C. 2015, 'Testing the nursing worklife model in Canada and Australia: a multi-group comparison study', *International Journal of Nursing Studies*, vol. 52, no. 2, pp. 525-34.

Rose, L., Blackwood, B., Egerod, I., Haugdahl, H., Hofhuis, J., Isfort, M., Kydonaki, K., Schubert, M., Sperlinga, R. & Spronk, P. 2011, 'Decisional responsibility for mechanical ventilation and weaning: an international survey', *Critical Care*, vol. 15, no. 6, pp. R25 1-8.

Rose, L., Nelson, S., Johnston, L. & Presneill, J. 2008, 'Workforce profile, organisation structure and role responsibility for ventilation and weaning practices in Australia and New Zealand intensive care units', *Journal of Clinical Nursing*, vol. 17, no. 8, pp. 1035-43.

Rosenthal, J. 2000, 'Parallel computing and Monte Carlo algorithms', *Far East Journal of Theoretical Statistics*, vol. 4, no. 2, pp. 207-36.

Rosenthal, V., Maki, D., Rodrigues, C., Alvarez-Moreno, C., Leblebicioglu, H., Sobreyra-Oropeza, M., Berba, R., Madani, N., Medeiros, E., Cuellar, L., Mitrev, Z., Duenas, L., Guanche-Garcell, H., Mapp, T., Kanj, S. & Fernandez-Hidalgo, R. 2010, 'Impact of International Nosocomial Infection Control Consortium (INICC) strategy on central line-associated bloodstream infection rates in the intensive care units of 15 developing countries', *Infection Control and Hospital Epidemiology*, vol. 31, no. 12, pp. 1264-72.

Rosenthal, V., Todi, S., Alvarez-Moreno, C., Pawar, M., Karlekar, A., Zeggwagh, A., Mitrev, Z., Udwadia, F., Navoa-Ng, J., Chakravarthy, M., Salomao, R., Sahu, S., Dilek, A., Kanj, S.S., Guanche-Garcell, H., Cuellar, L., Ersoz, G., Nevzat-Yalcin, A., Jaggi, N., Medeiros, E., Ye, G., Akan, O., Mapp, T., Castaneda-Sabogal, A., Matta-Cortes, L., Sirmatel, F., Olarte, N., Torres-Hernandez, H., Barahona-Guzman, N., Fernandez-Hidalgo, R., Villamil-Gomez, W., Sztokhamer, D., Forciniti, S., Berba, R., Turgut, H., Bin, C., Yang, Y., Perez-Serrato, I., Lastra, C., Singh, S., Ozdemir, D. & Ulusoy, S. 2012, 'Impact of a multidimensional infection control strategy on catheter-associated urinary tract infection rates in the adult intensive care units of 15 developing countries: findings of the International Nosocomial Infection Control Consortium', *Infection*, vol. 40, no. 5, pp. 517-26.

Rossi, C., Simini, B., Brazzi, L., Rossi, G., Radrizzani, D., Iapichino, G. & Bertolini, G. 2006, 'Variable costs of ICU patients: a multicenter prospective study', *Intensive Care Medicine*, vol. 32, no. 4, pp. 545-52.

Sablonnière, R., Tougas, F., Sablonnière, É. & Debrosse, R. 2012, 'Profound organizational change, psychological distress and burnout symptoms: the mediator role of collective relative deprivation', *Group Processes & Intergroup Relations*, vol. 15, no. 6, pp. 776-90.

Sagana, R. & Hyzy, R. 2013, 'Achieving zero central line–associated bloodstream infection rates in your intensive care unit', *Critical Care Clinics*, vol. 29, no. 1, pp. 1-9.

Sakr, Y., Moreira, C., Rhodes, A., Ferguson, D., Kleinpell, R., Pickkers, P., Kuiper, M., Lipman, J. & Vincent, J. 2015, 'The impact of hospital and icu organizational factors on outcome in critically ill patients: results from the extended prevalence of infection in intensive care study', *Critical Care Medicine* vol. 43, no. 3, pp. 519-26.

Salvatierra, G., Bindler, R., Corbett, C., Roll, J. & Daratha, K. 2014, 'Rapid response team implementation and in-hospital mortality', *Critical Care Medicine*, vol. 42, no. 9, pp. 2001-6.

Samur, M. & Intepeler, S. 2016, 'Factors influencing nurses’ perceptions of occupational safety', *Archives of Environmental & Occupational Health*, vol. 72, no. 1, pp. 45-52.

Santamaria, J., Duke, G., Pilcher, D. & Cooper, J. 2011, 'After-hours discharge from ICU is a risk factor for in-hospital mortality in a large multi-center prospective study', *American Journal of Respiratory and Critical Care Medicine*, vol. 183, no. 1, p. A4127.

Santamaria, J., Duke, G., Pilcher, D., Cooper, J., Moran, J. & Bellomo, R. 2015, 'The timing of discharge from ICU and subsequent mortality: a prospective multi-center study', *American Journal of Respiratory and Critical Care Medicine*, vol. 191, no. 9, pp. 1033-9.

Santamaria, J., Duke, G., Pilcher, D., Moran, J. & Bellomo, R. 2016, 'The timing of discharge from the intensive care unit and subsequent mortality: a prospective, multicenter study', *Survey of Anesthesiology*, vol. 60, no. 3, pp. 103-4.

Sasabuchi, Y., Yasunaga, H., Matsui, H., Lefor, A., Horiguchi, H., Fushimi, K. & Sanui, M. 2015, 'The volume-outcome relationship in critically ill patients in relation to the icu-to-hospital bed ratio', *Critical Care Medicine*, vol. 43, no. 6, pp. 1239-45.

Sawatzky, J., Enns, C. & Legare, C. 2015, 'Identifying the key predictors for retention in critical care nurses', *Journal of Advanced Nursing*, vol. 71, no. 10, pp. 2315-25.

Scala, R. 2012, 'Respiratory high-dependency care units for the burden of acute respiratory failure', *European Journal of Internal Medicine*, vol. 23, no. 4, pp. 302-8.

Scales, D. & Rubenfeld, G. 2016, 'The Organization of Critical Care', *Handbook of Intensive Care Organization and Management*, Imperial College Press, Singapore.

Scheithauer, S., Batzer, B., Dangel, M., Passweg, J. & Widmer, A. 2017, 'Workload impacts hand hygiene even in a highly trained and well-staffed setting: a prospective 365/7/24 observational study', *Journal of Hospital Infection*, vol. 97, no. 1, pp. 11-6.

Schreiter, D. & Saeger, H. 2011, 'What are the conditions for praciticing intersdisciplinary intensive care?', *Central Sheet for Surgery*, vol. 136, no. 1, pp. 106-12.

Seddon, M., Hocking, C., Mead, P. & Simpson, C. 2011, 'Aiming for zero: decreasing central line associated bacteraemia in the intensive care unit', *New Zealand Medical Journal*, vol. 124, no. 1339, pp. 9-21.

Selvan, K., Edriss, H., Sigler, M. & Tseng, J. 2014, 'Self-extubation in ICU patients', *Southwest Respiratory and Critical Care Chronicles*, vol. 2, no. 8, pp. 31-4.

Seppelt, I. 2013, 'Australia: Where Are We Going?', in D. Crippen (ed.), *ICU Resource Allocation in the New Millennium*, Springer, New York, pp. 107-12.

Seynaeve, S., Verbrugghe, W., Claes, B., Vandenplas, D., Reyntiens, D. & Jorens, P. 2011, 'Adverse drug events in intensive care units: a cross-sectional study of prevalence and risk factors', *American Journal of Critical Care*, vol. 20, no. 6, pp. e131-e40.

Shabot, M., Monroe, D., Inurria, J., Garbade, D. & France, A. 2013, 'Memorial Hermann: high reliability from board to bedside', *The Joint Commission Journal on Quality and Patient Safety*, vol. 39, no. 6, pp. 253-7.

Shahin, E., Dassen, T. & Halfens, R. 2009, 'Incidence, prevention and treatment of pressure ulcers in intensive care patients: A longitudinal study', *International Journal of Nursing Studies*, vol. 46, no. 4, pp. 413-21.

Shahul, S., Hacker, M., Novack, V., Mueller, A., Shaefi, S., Mahmood, B., Ali, S.H. & Talmor, D. 2014, 'The effect of hospital volume on mortality in patients admitted with severe sepsis', *PloS one*, vol. 9, no. 9, p. e108754.

Shamali, M., Shahriari, M., Babaii, A. & Abbasinia, M. 2015, 'Comparative study of job burnout among critical care nurses with fixed and rotating shift schedules', *Nursing and Midwifery Studies*, vol. 4, no. 3, pp. e27766 1 - 6.

Shekelle, P. 2013, 'Nurse-patient ratios as a patient safety strategy', *Annals of Internal Medicine*, vol. 158, no. Supplement, pp. 404-9.

Shirey, M. 2009, 'Authentic leadership, organizational culture, and healthy work environments', *Critical Care Nursing Quarterly*, vol. 32, no. 3, pp. 189-98.

Shorr, A., Choe, Y. & Linde-Zwirble, W. 2011, 'Delayed ICU admission with community-acquired severe sepsis greatly increases mortality and resource use', *Critical Care*, vol. 15, no. Suppl 1, pp. 301-3.

Shuhaiber, J., Isaacs, A. & Sedrakyan, A. 2015, 'The effect of center volume on in-hospital mortality after aortic and mitral valve surgical procedures: a population-based study', *The Annals of Thoracic Surgery*, vol. 100, no. 4, pp. 1340-6.

Silva, M., Sousa, R. & Padilha, K. 2011, 'Factors associated with death and readmission into the intensive care unit', *Revista Latino-Americana de Enfermagem*, vol. 19, no. 4, pp. 911-9.

Simon, M. & Goes, J. 2011, 'Analysis of Qualitative Data', in M. Simon (ed.), *Dissertation and Scholarly Research: Recipes for Success.*, Createspace Independent, Seattle, WA, p. 332.

Singer, J., Kohlwes, J., Bent, S., Zimmerman, L. & Eisner, M. 2010, 'The impact of a "low-intensity" versus "high-intensity" medical intensive care unit on patient outcomes in critically ill veterans', *Journal of Intensive Care Medicine* vol. 25, no. 4, pp. 233-9.

Singer, S., Rivard, P., Hayes, J., Shokeen, P., Gaba, D. & Rosen, A. 2013, 'Improving patient care through leadership engagement with frontline staff: a Department of Veterans Affairs case study', *Joint Commission Journal on Quality and Patient Safety*, vol. 39, no. 8, pp. 349-60.

Singh, M., Nayyar, V., Clark, P. & C., K. 2010, 'Does after-hours discharge of ICU patients influence outcome?', *Critical Care and Resuscitation*, vol. 12, no. 3, pp. 156-61.

Sjoding, M., Prescott, H., Wunsch, H., Iwashyna, T. & Cooke, C. 2015, 'Hospitals with the highest intensive care utilization provide lower quality pneumonia care to the elderly', *Critical Care Medicine*, vol. 43, no. 6, p. 1178.

Skinner, E., Warrillow, S. & Denehy, L. 2015, 'Organisation and resource management in the intensive care unit: a critical review', *International Journal of Therapy and Rehabilitation*, vol. 22, no. 4, pp. 187-96.

Soares, M., Bozza, F., Angus, D., Japiassú, A., Viana, W., Costa, R., Brauer, L., Mazza, B., Corrêa, T., Nunes, A., Lisboa, T., Colombari, F., Maciel, A., Azevedo, L., Damasceno, M., Fernandes, H., Cavalcanti, A., do Brasil, P., Kahn, J. & Salluh, J. 2015, 'Organizational characteristics, outcomes, and resource use in 78 Brazilian intensive care units: the ORCHESTRA study', *Intensive Care Medicine*, vol. 41, no. 12, pp. 2149-60.

Soares, M., Kahn, J., Bozza, F., Lisboa, T., Azevedo, L., Viana, W., Brauer, L., Brasil, P., Angus, D. & Salluh, J. 2015, 'Organizational factors and patient outcomes in Brazilian ICUs: the ORCHESTRA study', *Critical Care*, vol. 19, no. Suppl 1, p. P500.

Soh, K., Soh, K. & Davidson, P. 2013, 'The role of culture in quality improvement in the intensive care unit: A literature review', *Journal of Hospital Administration*, vol. 2, no. 2, pp. 97-104.

Sokol-Hessner, L., White, A., Davis, K., Herzig, S. & Hohmann, S. 2016, 'Interhospital transfer patients discharged by academic hospitalists and general internists: characteristics and outcomes', *Journal of Hospital Medicine*, vol. 11, no. 4, pp. 245-50.

Soltani, S., Ingolfsson, A., Zygun, D., Stelfox, H., Hartling, L., Featherstone, R., Opgenorth, D. & Bagshaw, S. 2015, 'Quality and performance measures of strain on intensive care capacity: a protocol for a systematic review', *Systematic Reviews*, vol. 4, no. 1, pp. 1-6.

Spence Laschinger, H., Almost, J. & Tuer-Hodes, D. 2003, 'Workplace empowerment and magnet hospital characteristics: making the link', *Journal of Nursing Administration*, vol. 33, no. 7-8, pp. 410-22.

Squires, M., Tourangeau, A., Spence Laschinger, H. & Doran, D. 2010, 'The link between leadership and safety outcomes in hospitals', *Journal of Nursing Management*, vol. 18, no. 8, pp. 914-25.

Stalpers, D., de Brouwer, B., Kaljouw, M. & Schuurmans, M. 2015a, 'Associations between characteristics of the nurse work environment and five nurse-sensitive patient outcomes in hospitals: a systematic review of literature', *International Journal of Nursing Studies*, vol. 52, no. 4, pp. 817-35.

Stalpers, D., de Brouwer, B.J., Kaljouw, M.J. & Schuurmans, M.J. 2015b, 'Associations between Characteristics of the Nurse Work Environment and five Nurse-Sensitive Patient Outcomes in Hospitals: A systematic review of literature', *International Journal of Nursing Studies*.

Stalpers, D., van der Linden, D., Kaljouw, M. & Schuurmans, M. 2017, 'Nurse-perceived quality of care in intensive care units and associations with work environment characteristics: a multicentre survey study', *Journal of Advanced Nursing*, vol. 73, no. 6, pp. 1482-90.

Stanley, D. 2014, 'Clinical leadership characteristics confirmed', *Journal of Research in Nursing*, vol. 19, no. 2, pp. 118-28.

Steege, L., Pinekenstein, B., Arsenault Knudsen, É. & Rainbow, J. 2017, 'Exploring nurse leader fatigue: a mixed methods study', *Journal of Nursing Management*, vol. 25, no. 4, pp. 276-86.

Steege, L. & Rainbow, J. 2017, 'Fatigue in hospital nurses — ‘Supernurse’ culture is a barrier to addressing problems: a qualitative interview study', *International Journal of Nursing Studies*, vol. 67, pp. 20-8.

Stock, G. & McDermott, C. 2011, 'Operational and contextual drivers of hospital costs', *Journal of Health Organization and Management*, vol. 25, no. 2, pp. 142-58.

Stockwell, D. & Slonim, A. 2006, 'Quality and safety in the intensive care unit', *Journal of Intensive Care Medicine*, vol. 21, no. 4, pp. 199-210.

Stoddart, C. 2010, *Adult Critical Care Nursing Workforce Report*, Department of Health, Nursing and Midwifery Office, Perth, Australia.

Stone, P., Larson, E., Mooney-Kane, C., Smolowitz, J., Lin, S. & Dick, A. 2006, 'Organizational climate and intensive care unit nurses' intention to leave', *Critical Care Medicine*, vol. 34, no. 7, pp. 1907-12.

Stone, P., Mooney-Kane, C., Larson, E., Horan, T., Glance, L., Zwanziger, J. & Dick, A. 2007, 'Nurse working conditions and patient safety outcomes', *Medical Care*, vol. 45, no. 6, pp. 571-8.

Stordeur, S. & D'Hoore, W. 2007, 'Organizational configuration of hospitals succeeding in attracting and retaining nurses', *Journal of Advanced Nursing*, vol. 57, no. 1, pp. 45-58.

Strand, T. & Lindgren, M. 2010, 'Knowledge, attitudes and barriers towards prevention of pressure ulcers in intensive care units: a descriptive cross-sectional study', *Intensive and Critical Care Nursing*, vol. 26, no. 6, pp. 335-42.

Strauch, U., Bergmans, D., Marx, G. & Roekaerts, P. 2015, 'The changing landscape of intensive care medicine', *Acta Anæsthesiologica Belgica*, vol. 66, no. 2, pp. 1-5.

Subramanian, P., Choy, K., Gobal, S., Mansor, M. & Ng, K. 2013, 'Impact of education on ventilator-associated pneumonia in the intensive care unit', *Singapore Medical Journal*, vol. 54, no. 5, pp. 281-4.

Suhonen, R., Stolt, M., Katajisto, J. & Leino-Kilpi, H. 2015, 'Review of sampling, sample and data collection procedures in nursing research - an example of research on ethical climate as perceived by nurses', *Scandinavian Journal of Caring Sciences*, vol. 29, no. 4, pp. 843-58.

Suntharalingam, G., Handy, J. & Walsh, A. 2014, 'Regionalisation of critical care: can we sustain an intensive care unit in every hospital?', *Anaesthesia*, vol. 69, no. 10, pp. 1069-73.

Sutcliffe, K., Paine, L. & Pronovost, P. 2017, 'Re-examining high reliability: actively organising for safety', *BMJ Quality & Safety*, vol. 26, no. 3, pp. 248-51.

Szilagyi, A., Dioszeghy, C. & Varga, K. 2008, 'Psychologists working as members of the intensive care team could reduce the length of stay', *Orvosi Hetilap*, vol. 149, no. 49, pp. 2329-33.

Tabachnick, B. & Fidell, L. 2001, *Using Multivariate statistics*, 1st edn, Harper Collins, California State University Northridge.

Tabachnick, B. & Fidell, L. 2013, *Using Multivariate Statistics*, 6th edn, Pearson, California State University, Northridge.

Takala, J. 2014, 'A History of Intensive Care Medicine', in E. Eger Ii, L. Saidman & R. Westhorpe (eds), *The Wondrous Story of Anesthesia*, Springer New York, pp. 785-98.

Talaat, M., Hafez, S., Saied, T., Elfeky, R., El-Shoubary, W. & Pimentel, G. 2010, 'Surveillance of catheter-associated urinary tract infection in 4 intensive care units at Alexandria university hospitals in Egypt', *American Journal of Infection Control*, vol. 38, no. 3, pp. 222-8.

Talib, F. & Rahman, Z. 2015, 'An interpretive structural modelling for sustainable healthcare quality dimensions in hospital services', *International Journal of Qualitative Research in Services*, vol. 2, no. 1, pp. 28-46.

Tan, S., Hakkaart-van Roijen, L., Al, M., Bouwmans, C., Hoogendoorn, M., Spronk, P. & Bakker, J. 2008, 'Review of a large clinical series: a microcosting study of intensive care unit stay in the Netherlands', *Journal of Intensive Care Medicine*, vol. 23, no. 4, pp. 250-7.

Tanaka, M. & Ramaiah, R. 2014, 'Demand versus supply in intensive care: an ever-growing problem', *Critical Care*, vol. 18, no. Suppl 1, p. P9.

Tao, H., Ellenbecker, C., Wang, Y. & Li, Y. 2015, 'Examining perceptions of job satisfaction and intentions to leave among ICU nurses in China', *International Journal of Nursing Sciences*, vol. 2, no. 2, pp. 140-8.

Teo, S., Pick, D., Newton, C., Yeung, M. & Chang, E. 2013, 'Organisational change stressors and nursing job satisfaction: the mediating effect of coping strategies', *Journal of Nursing Management*, vol. 21, no. 6, pp. 878-87.

Terblanche, M. & Adhikari, N. 2006, 'The evolution of intensive care unit performance assessment', *Journal of Critical Care*, vol. 21, no. 1, pp. 19-22.

Thille, A., Harrois, A., Schortgen, F., Brun-Buisson, C. & Brochard, L. 2011, 'Outcomes of extubation failure in medical intensive care unit patients', *Critical Care Medicine*, vol. 39, no. 12, pp. 2612-8.

Thomas, B., Ciliska, D., Dobbins, M. & Micucci, S. 2004, 'A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions', *Worldviews on Evidence Based Nursing*, vol. 1, no. 3, pp. 176-84.

Thomas, K., Wright, S., Watson, G., Baker, C., Stafford, V., Wade, C., Chadwick, T., Mansfield, L., Wilkinson, J., Shen, J., Deverill, M., Bonner, S., Hugill, K., Howard, P., Henderson, A., Roy, A., Furneval, J. & Baudouin, S. 2015, 'Extra Physiotherapy in Critical Care (EPICC) Trial Protocol: a randomised controlled trial of intensive versus standard physical rehabilitation therapy in the critically ill', *BMJ Open*, vol. 5, no. 5, p. p.e008035.

Thompson, D., Clemmer, T., Applefield, J., Crippen, D., Jastremski, M., Lucas, C., Pollack, M. & Wedel, S. 1994, 'Regionalization of critical care medicine: task force report of the American College of Critical Care Medicine', *Critical Care Medicine*, vol. 22, no. 8, pp. 1306-13.

Thompson, D., Hamilton, D., Cadenhead, C., Swoboda, S., Schwindel, S., Anderson, D., Schmitz, E., St. Andre, A., Axon, D., Harrell, J., Harvey, M., Howard, A., Kaufman, D. & Petersen, C. 2012, 'Guidelines for intensive care unit design', *Critical Care Medicine*, vol. 40, no. 5, pp. 1586-600

Thompson, D., Hsu, Y., Chang, B. & Marsteller, J. 2013, 'Impact of nursing staffing on patient outcomes in intensive care unit', *Journal of Nursing Care*, vol. 2, no. 3, pp. 128-34.

Tierney, L. & Conroy, K. 2014, 'Optimal occupancy in the ICU: a literature review', *Australian Critical Care* vol. 27, no. 2, pp. 77-84.

Timmers, T., Hulstaert, P. & Leenen, L. 2014, 'Patient outcomes can be associated with organizational changes: a quality improvement case study', *Critical Care Nursing Quarterly*, vol. 37, no. 1, pp. 125-34

Timmers, T.K., Joore, H. & Leenen, L. 2014, 'Changes after transformation from a specialized surgical unit to a general mixed intensive care unit', *Critical Care Nursing Quarterly*, vol. 37, no. 1, pp. 115-24.

Tironi, M., Teles, J., Barros, D., Vieira, D., da Silva Filho, C., Martins Júnior, D., Matos, M. & Nascimento Sobrinho, C. 2016, 'Prevalence of burnout syndrome in intensivist doctors in five Brazilian capitals', *Revista Brasileira de Terapia Intensiva*, vol. 28, no. 3, pp. 270-7.

Torra, L., Abillama, F., Amin, P., Christian, M., Joynt, G., Myburgh, J., Nates, J., Pelosi, P., Sprung, C., Topeli, A., Vincent, J., Yeager, S. & Zimmerman, J. 2016, 'Triage decisions for ICU admission: report from the task force of the World Federation of Societies of Intensive and Critical Care Medicine', *Journal of Critical Care*, vol. 36, pp. 301-5.

Tourangeau, A. 2011, 'Mortality rate as a nurse-sensitive outcome', in D. Doran (ed.), *Nursing Outcomes: The State of the Science*, Jones & Bartlett, Sudbury, pp. 409-34.

Tourangeau, A., Cranley, L., Laschinger, H. & Pachis, J. 2010, 'Relationships among leadership practices, work environments, staff communication and outcomes in long-term care', *Journal of Nursing Management*, vol. 18, no. 8, pp. 1060-72.

Tourangeau, A., Cummings, G., Cranley, L., Ferron, E. & Harvey, S. 2010, 'Determinants of hospital nurse intention to remain employed: broadening our understanding', *Journal of Advanced Nursing*, vol. 66, no. 1, pp. 22-32.

Town, J., Churpek, M., Yuen, T., Huber, M., Kress, J. & Edelson, D. 2014, 'Relationship between ICU bed availability, ICU readmission, and cardiac arrest in the general wards', *Critical Care Medicine*, vol. 42, no. 9, pp. 2037-41

Treggiari, M., Martin, D., Yanez, D., Caldwell, E., Hudson, L. & Rubenfeld, G. 2007, 'Effect of ICU organizational model and structure on outcomes in patients with acute lung injury', *American Journal of Respiratory and Critical Care Medicine*, vol. 176, no. 7, pp. 685-90.

Tropello, S., Ravitz, A., Romig, M., Pronovost, P. & Sapirstein, A. 2013, 'Enhancing the quality of care in the intensive care unit: a systems engineering approach', *Critical Care Clinics*, vol. 29, no. 1, pp. 113-24.

Tsai, Y. 2011, 'Relationship between organizational culture, leadership behavior and job satisfaction', *BMC Health Services Research*, vol. 11, no. 1, pp. 98-107.

Twigg, D. & McCullough, K. 2014, 'Nurse retention: a review of strategies to create and enhance positive practice environments in clinical settings', *International Journal of Nursing Studies*, vol. 51, no. 1, pp. 85-92.

Ulrich, B., Lavandero, R., Woods, D. & Early, S. 2014a, 'Critical care nurse work environments 2013: a status report', *Critical Care Nurse*, vol. 34, no. 4, pp. 64-79.

Ulrich, B.T., Lavandero, R., Woods, D. & Early, S. 2014b, 'Critical Care Nurse Work Environments 2013: A Status Report', *Critical Care Nurse*, vol. 34, no. 4, pp. 64-79.

Vahey, D., Aiken, L., Sloane, D., Clarke, S. & Vargas, D. 2004, 'Nurse burnout and patient satisfaction', *Medical Care*, vol. 42, no. 2, pp. 57-66.

Valentin, A. & Ferdinande, P. 2011, 'Recommendations on basic requirements for intensive care units: structural and organizational aspects: ESICM working group on quality improvement.', *Intensive Care Medicine*, vol. 37, no. 10, pp. 1575-87.

Van Bogaert, P., Clarke, S., Roelant, E., Meulemans, H. & Van de Heyning, P. 2010, 'Impacts of unit-level nurse practice environment and burnout on nurse-reported outcomes: a multilevel modelling approach', *Journal of Clinical Nursing*, vol. 19, no. 11-12, pp. 1664-74.

Van Bogaert, P., Clarke, S., Vermeyen, K., Meulemans, H. & Van de Heyning, P. 2009, 'Practice environments and their associations with nurse-reported outcomes in Belgian hospitals: Development and preliminary validation of a Dutch adaptation of the revised Nursing Work Index', *International Journal of Nursing Studies*, vol. 46, no. 1, pp. 55-65.

Van Bogaert, P., Kowalski, C., Weeks, S.M. & Clarke, S.P. 2013, 'The relationship between nurse practice environment, nurse work characteristics, burnout and job outcome and quality of nursing care: a cross-sectional survey', *International journal of nursing studies*, vol. 50, no. 12, pp. 1667-77.

Van Bogaert, P., Olaf, T., Weeks, S., Van heusden, D., Wouters, K. & Franck, E. 2013, 'Nursing unit teams matter: impact of unit-level nurse practice environment, nurse work characteristics, and burnout on nurse reported job outcomes, and quality of care, and patient adverse events', *International Journal of Nursing Studies*, vol. 51, no. 8, pp. 1123-34.

Van Bogaert, P., Peremans, L., Diltour, N., Dilles, T., Van Rompaey, B. & Havens, D. 2016, 'Staff nurses' perceptions and experiences about structural empowerment: a qualitative phenomenological study', *PloS one*, vol. 11, no. 4, p. e0152654.

Van Bogaert, P., Peremans, L., Van Heusden, D., Verspuy, M., Kureckova, V., Van de Cruys, Z. & Franck, E. 2017, 'Predictors of burnout, work engagement and nurse reported job outcomes and quality of care: a mixed method study', *BMC Nursing*, vol. 16, no. 1, pp. 1-14.

van der Sluijs, A., van Slobbe-Bijlsma, E., Chick, S., Vroom, M., Dongelmans, D. & Vlaar, A. 2017, 'The impact of changes in intensive care organization on patient outcome and cost-effectiveness—a narrative review', *Journal of Intensive Care*, vol. 5, no. 13, pp. 1 - 8.

van der Sluis, F., Slagt, C., Liebman, B., Beute, J., Mulder, J. & Engel, A. 2011, 'The impact of open versus closed format ICU admission practices on the outcome of high risk surgical patients: a cohort analysis', *BMC Surg*, vol. 11, p. 18.

van der Veer, S., de Vos, M.L., van der Voort, P.H., Peek, N., Abu-Hanna, A., Westert, G., Graafmans, W., Jager, K. & de Keizer, N. 2013, 'Effect of a multifaceted performance feedback strategy on length of stay compared with benchmark reports alone: a cluster randomized trial in intensive care', *Critical Care Medicine*, vol. 41, no. 8, pp. 1893-904.

van der Voort, P., van der Veer, S. & de Vos, M. 2012, 'The use of indicators to improve the quality of intensive care: theoretical aspects and experiences from the Dutch intensive care registry', *Acta Anaesthesiologica Scandinavica*, vol. 56, no. 9, pp. 1084-91.

van Mol, M., Kompanje, E., Benoit, D., Bakker, J. & Nijkamp, M. 2015, 'The prevalence of compassion fatigue and burnout among healthcare professionals in intensive care units: a systematic review', *PLoS ONE*, vol. 10, no. 8, p. e0136955.

Verburg, I., Holman, R., Dongelmans, D., de Jonge, E. & de Keizer, N. 2018, 'Is patient length of stay associated with intensive care unit characteristics?', *Journal of Critical Care*, vol. 43, pp. 114-25.

Vianna, A., Rangel, D., Alves, A., Aguiar, A., Adolphsson, S., Bockorny, B., Farias, C. & Chiarello, A. 2007, 'Unplanned extubation in the intensive care unit: what are the consequences?', *Critical Care*, vol. 11, no. (Suppl 3), p. 66.

Victorian Government DHHS 2009, *Victoria's intensive care services future directions*, Victorian Government Melbourne

Vincent, J. 2016, 'The future of critical care medicine: integration and personalization', *Critical Care Medicine*, vol. 44, no. 2, pp. 386-9.

Vincent, J. 2017, 'Evidence supports the superiority of closed ICUs for patients and families: Yes', *Intensive Care Medicine*, vol. 43, no. 1, pp. 122-3.

Vincent, J. & Creteur, J. 2017, 'The hospital of tomorrow in 10 points', *Critical Care*, vol. 21, no. 1, pp. 1-4.

Vincent, J. & Rubenfeld, G. 2015, 'Does intermediate care improve patient outcomes or reduce costs?', *Critical Care*, vol. 19, no. 1, pp. 89-90.

Vogus, T. & Iacobucci, D. 2016, 'Creating highly reliable health care', *Industrial and Labor Relations Review*, vol. 69, no. 4, pp. 911-38.

von Elm, E., Altman, D., Egger, M., Pocock, S., Gøtzsche, P. & Vandenbroucke, J. 2007, 'The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies', *Preventive Medicine*, vol. 45, no. 4, pp. 247-51.

Wagner, C., Mannion, R., Hammer, A., Groene, O., Arah, O.A., Dersarkissian, M. & Suñol, R. 2014, 'The associations between organizational culture, organizational structure and quality management in European hospitals', *International Journal for Quality in Health Care*, vol. 26, no. Supp 1, pp. 74-80.

Wagner, J., Gabler, N., Ratcliffe, S., Brown, S., Strom, B. & Halpern, S. 2013, 'Outcomes among patients discharged from busy intensive care units', *Annals of Internal Medicine*, vol. 159, no. 7, pp. 447-55.

Walker, K., Fitzgerald, K. & Duff, J. 2014, 'Supporting a healthy culture: results of the practice environment scale, Australia in a Magnet® designated hospital', *Journal of Nursing Administration*, vol. 44, no. 12, pp. 653-8.

Walker, K., Mayo, R., Camire, L. & Kearney, C. 2013, 'Effectiveness of integration of palliative medicine specialist services into the intensive care unit of a community teaching hospital', *Journal of Palliative Medicine*, vol. 16, no. 10, pp. 1237-41.

Walkey, A. & Wiener, R. 2014, 'Hospital case volume and outcomes among patients hospitalized with severe sepsis', *American Journal of Respiratory and Critical Care Medicine*, vol. 189, no. 5, pp. 548-55.

Wallace, D., Seymour, C. & Kahn, J. 2017, 'Hospital-level changes in adult ICU bed supply in the United States', *Critical Care Medicine*, vol. 45, no. 1, pp. e67-e76.

Wallace, F., Alexander, P., Spencer, C., Naisbitt, J., Moore, J. & McGrath, B. 2015, 'A comparison of ventilator-associated pneumonia rates determined by different scoring systems in four intensive care units in the North West of England', *Anaesthesia*, vol. 70, no. 11, pp. 1274-80.

Wallis, L. 2015, 'The top nursing news stories of 2014', *American Journal of Nursing*, vol. 115, no. 1, p. 15.

Ward, N., Afessa, B., Kleinpell, R., Tisherman, S., Ries, M., Howell, M., Halpern, N. & Kahn, J. 2013, 'Intensivist/patient ratios in closed ICUs: a statement from the Society of Critical Care Medicine Taskforce on ICU staffing', *Critical Care Medicine*, vol. 41, no. 2, pp. 638-45.

Ward, N. & Howell, M. 2015, 'Intensivist-to-patient ratios in ICUs: is there a number?', *Current Opinions in Anaesthesiology*, vol. 28, no. 2, pp. 172-9.

Warshawsky, N. & Havens, D. 2011, 'Global Use of the Practice Environment Scale of the Nursing Work Index', *Nursing Research*, vol. 60, no. 1, pp. 17-31.

Warshawsky, N., Rayens, M., Stefaniak, K. & Rahman, R. 2013, 'The effect of nurse manager turnover on patient fall and pressure ulcer rates', *Journal of Nursing Management*, vol. 21, no. 5, pp. 725-32.

Wasden, M. 2017, 'High-reliability principles must be tied to value-based outcomes', *Frontiers of Health Services Management*, vol. 33, no. 4, pp. 26-32.

Watkins, M. 2000, 'Monte Carlo PCA for parallel analysis [computer software]', in E.P. Associates (ed.)State College, PA.

Webb, A. 2016, *Handbook of Intensive Care Organization and Management*, Imperial College Press, London.

Weigl, M., Stab, N., Herms, I., Angerer, P., Hacker, W. & Glaser, J. 2016, 'The associations of supervisor support and work overload with burnout and depression: a cross-sectional study in two nursing settings', *Journal of Advanced Nursing*, vol. 72, no. 8, pp. 1774-88.

Weil, M. & Shoemaker, W. 2004, ' Pioneering contributions of Peter Safar to intensive care and the founding of the Society of Critical Care Medicine', *Critical Care Medicine*, vol. 32, no. (suppl), pp. S8-S10.

Weil, M. & Tang, W. 2011, 'From intensive care to critical care medicine: a historical perspective', *American Journal of Respiratory & Critical Care Medicine*, vol. 183, no. 11, pp. 1451-3.

Weissman, G., Gabler, N., Brown, S. & Halpern, S. 2015, 'Intensive care unit capacity strain and adherence to prophylaxis guidelines', *Journal of Critical Care*, vol. 30, no. 6, pp. 1303-9.

Welch, C., Harrison, D. & Rowan, K. 2008, 'Trends in outcomes from adult generalcritical care units: potential outcome-based quality indicators other thancase-mix adjusted mortality ', *Journal International College of Surgery* vol. 9, no. 3, pp. 220-3.

Weled, B., Adzhigirey, L., Hodgman, T., Brilli, R., Spevetz, A., Kline, A., Montgomery, V., Puri, N., Tisherman, S. & Vespa, P. 2015, 'Critical care delivery: the importance of process of care and ICU structure to improved outcomes: an update from the American College of Critical Care Medicine Task Force on models of critical care', *Critical Care Medicine*, vol. 43, no. 7, pp. 1520-5.

Welp, A., Meier, L. & Manser, T. 2016, 'The interplay between teamwork, clinicians' emotional exhaustion, and clinician-rated patient safety: a longitudinal study', *Critical Care*, vol. 20, no. 1, pp. 1-10.

Weng, S., Kim, S. & Wu, C. 2017, 'Underlying influence of perception of management leadership on patient safety climate in healthcare organizations – a mediation analysis approach', *International Journal for Quality in Health Care* vol. 29, no. 1, pp. 111-6.

West, E., Barron, D., Harrison, D., Rafferty, A., Rowan, K. & Sanderson, C. 2014, 'Nurse staffing, medical staffing and mortality in Intensive Care: an observational study', *International Journal of Nursing Studies*, vol. 51, no. 5, pp. 781-94.

White, V., Currey, J. & Botti, M. 2011, 'Multidisciplinary team developed and implemented protocols to assist mechanical ventilation weaning: a systematic review of literature', *Worldviews on Evidence-Based Nursing*, vol. 8, no. 1, pp. 51-9.

Whittemore, R. & Knafl, K. 2005, 'The integrative review: updated methodology', *Journal of Advanced Nursing*, vol. 52, no. 5, pp. 546-53.

Whittle, R. & Shelton, J. 2012, 'Outcome from intensive care and measuring performance', *Surgery*, vol. 30, no. 5, pp. 244-8.

Wilcox, E., Harrison, D., Short, A., Jonas, M. & Rowan, K. 2014, 'Comparing mortality among adult, general intensive care units in England with varying consultant cover patterns: retrospective cohort study', *Critical Care*, vol. 18, no. 4, pp. 491-509.

Wiles, V. & Daffurn, K. 2002, *There's a Bird in my Hand and a Bear by the Bed: I Must be in ICU*, Sydney, Australia.

Willem, A., Buelens, M. & De Jonghe, I. 2007, 'Impact of organizational structure on nurses' job satisfaction: a questionnaire survey', *International Journal of Nursing Studies*, vol. 44, no. 6, pp. 1011-20.

Williams, G. 2009, 'Nursing Workforce Management in Intensive Care', in A. Gullo, P. Lumb, J. Besso & G. Williams (eds), *Intensive and Critical Care Medicine*, Springer, Milan, Italy, pp. 107-17.

Williams, T., Leslie, G., Brearley, L., Leen, T. & O'Brien, K. 2010, 'Discharge delay, room for improvement?', *Australian critical care : official journal of the Confederation of Australian Critical Care Nurses*, vol. 23, no. 3, pp. 141-9.

Wong, C.A., Cummings, G. & Ducharme, L. 2013, 'The relationship between nursing leadership and patient outcomes: a systematic review update', *Journal of Nursing Management*, vol. 21, no. 5, pp. 709-24.

Wood, S., Coster, S. & Norman, I. 2014, 'Comparing the monitoring of patients transferred from a critical care unit to hospital wards at after-hours with day transfers: an exploratory, prospective cohort study', *Journal of Advanced Nursing*, vol. 70, no. 12, pp. 2757-66.

Worley, J., Vassar, M., Wheeler, D. & Barnes, L. 2008, 'Factor structure of scores from the Maslach Burnout Inventory a review and meta-analysis of 45 exploratory and confirmatory factor-analytic studies', *Educational and Psychological Measurement*, vol. 68, no. 5, pp. 797-823.

Wunsch, H., Gershengorn, H. & Scales, D. 2012, 'Economics of ICU organization and management', *Critical Care Clinics*, vol. 28, no. 1, pp. 25-37.

Wunsch, H., Harrison, D., Jones, A.R. & Rowan, K. 2014, 'The impact of the organization of high-dependency care on acute hospital mortality and patient flow for critically ill patients', *American Journal of Respiratory and Critical Care Medicine*, vol. 191, no. 2, pp. 186-93.

Xiao, S., Widger, K., Tourangeau, A. & Berta, W. 2017, 'Nursing process health care indicators: a scoping review of development methods', *Journal of Nursing Care Quality*, vol. 32, no. 1, pp. 32-9.

Xiao, T., Sanderson, P., Clayton, S. & Venkatesh, B. 2010, 'The ETTO principle and organisational strategies: a field study of ICU bed and staff management', *Cognition, Technology & Work*, vol. 12, no. 2, pp. 143-52.

Yerramilli, A., Katta, S., Kidambi, S., Kotari, N., Devulapally, S. & Sharma, S. 2016, 'Deep vein thrombosis prophylaxis in a tertiary care center: An observational study', *Apollo Medicine*, vol. 13, no. 1, pp. 37-41.

Yoo, E., Edwards, J., Dean, M. & Dudley, R. 2014, 'Multidisciplinary critical care and intensivist staffing: results of a statewide survey and association with mortality', *Journal of Intensive Care Medicine*, vol. 31, no. 5, pp. 325-32.

Young, M. & Birkmeyer, J. 2000, 'Potential reduction in mortality rates using an intensivist model to manage intensive care units', *Effective Clinical Practice*, vol. 3, no. 6, pp. 284-9.

Zack, J. 2008, 'Zeroing in on zero tolerance for central line-associated bacteremia', *American Journal of Infection Control*, vol. 36, no. 10, p. S176.

Zakhary, W., Turton, E. & Ender, J. 2016, 'Do we really need more intensive care unit beds?', *Annals of Translational Medicine*, vol. 4, no. 18, pp. 356-7.

Zampieri, F., Colombari, C., de Batista, L., Santoro, C., Haib, D. & Ladeira, J. 2013, 'Factors associated with prolonged ICU stay: a retrospective analysis', *Critical Care* vol. 17, no. 3, pp. 9-11.

Zarei, E., Khakzad, N., Reniers, G. & Akbari, R. 2016, 'On the relationship between safety climate and occupational burnout in healthcare organizations', *Safety Science*, vol. 89, pp. 1-10.

Zayan, N., Reizian, A. & Hamouda, G. 2013, 'Relationship between organizational climate and nurse outcomes', *Journal of American Science*, vol. 2, no. 9, pp. 184-92.

Zhang, L., You, L., Liu, K., Zheng, J., Fang, J., Lu, M., Lv, A., Ma, W., Wang, J., Wang, S., Wu, X., Zhu, X. & Bu, X. 2013, 'The association of chinese hospital work environment with nurse burnout, job satisfaction, and intention to leave', *Nursing Outlook*, vol. 62, no. 2, pp. 128-37.

Zimmerman, J. 2009, 'Intensive care unit occupancy: making room for more patients', *Critical Care Medicine*, vol. 37, no. 5, pp. 1794-5.

APPENDICES

1. Manuscript ICU Volume – Mortality 2014

(Copyright Permission [AUCC_232] [151221-000552] Elsevier Researcher Support: http://support.elsevier.com 22/12/2015).

Australian Critical Care 27 (2014) 157–164

Contents lists available at ScienceDirect

Australian Critical Care

journal homepage: www.elsevier.com/locate/aucc

The intensive care unit volume–mortality relationship, is bigger better? An integrative literature review

Brett Abbenbroek MPH[a,*], Christine M. Duffield PhD[b], Doug Elliott PhD[a]

[a] Faculty of Health, University of Technology, Sydney, 15 Broadway, Ultimo 2007, Australia
[b] Centre for Health Services Management, Faculty of Health, University of Technology, Sydney, 15 Broadway, Ultimo 2007, Australia

ARTICLE INFORMATION

Article history:
Received 2 November 2013
Received in revised form 27 January 2014
Accepted 11 February 2014

Keywords:
Critical care
Intensive care
Mortality
Outcome
Quality
Volume

ABSTRACT

Objective: To explore the association between patient volume in intensive care units (ICUs) and risk-adjusted mortality.
Background: Large multi-speciality ICUs are emerging in response to increasing demand for critical care. Consolidation of resources through regionalisation of services aims to contain costs and optimise demand management and operational synergies. Higher patient volumes in ICU have been associated with improved outcomes. Limited evidence exists, however, to suggest an optimal volume of patients in terms of risk-adjusted mortality.
Review method: Retrospective integrative literature review.
Data sources: EMBASE, PubMed and Cumulative Index to Nursing and Allied Health Literature electronic databases.
Inclusion criteria: Primary studies of risk adjusted mortality in adult ICU patients published between 1995 and 2012.
Exclusion criteria: Studies of admissions following elective procedures.
Results: Twenty quantitative observational studies were included in this review. Studies were primarily retrospective with three conducted prospectively. Nine studied mechanically ventilated patients, six included all admissions to ICU, three reported on patients with sepsis and one study each on patients post cardiac arrest and those receiving renal replacement therapy. A significant association was evident in sixteen studies suggesting a lower risk of adjusted mortality in higher-volume units. The association was not consistent across all diagnosis. A non-linear relationship observed in two studies noted no mortality benefit occurring above a volume threshold of 450 cases annually per diagnostic category and above 711 cases not specific to a diagnostic group.
Conclusion: Patient mortality may be improved in large capacity ICUs. However, the association is not consistent across all diagnostic groups. Risk adjusted mortality is increased in low volume ICUs. There appears to be a high volume threshold at which point the risk adjusted mortality benefit is also lost suggesting a window of optimal ICU organisational performance exists between low and high volumes. Further prospective research is recommended into clinical outcomes in high volume ICUs to explore association between organisational efficiency and quality of care.

Introduction

Internationally the demand for intensive care is growing and the resources required are significant.[1] Growth in demand, driven by increased patient acuity, multiple comorbidities, population ageing and increasing therapeutic complexity, leads to escalating costs.[2,3] In Australia, for example, during 2009/2010 there were 124,991 admissions to ICU accounting for 391,600 bed days.[4] At a cost of $4000 (AUD) per ICU day the estimated annual

DOI of CPD questions: http://dx.doi.org/10.1016/S1036-7314(14)00112-X.
* Corresponding author. Tel.: +61 243860413.
E-mail addresses: Brett.J.Abbenbroek@student.uts.edu.au, babbenbroek@gmail.com (B. Abbenbroek).

http://dx.doi.org/10.1016/j.aucc.2014.02.001
1036-7314/

expenditure was $1.56 billion.[5] Annual growth in demand compounds costs. In Australia from 2004 to 2010 demand for intensive care increased four per cent annually while in comparison the United States demand increased on average by ten per cent annually between 2000 and 2010.[4,6]

Organisational transformation in ICU is required to improve bed utilisation. Simply increasing bed capacity is not sustainable in terms of both economic and workforce requirements.[7] A key demand management strategy is networking between hospitals for the referral of critically ill patients to access definitive care.[8,9] Regionalisation, or consolidation of services into large capacity ICUs for a defined clinical network or geographic area, is being progressively adopted in many countries to concentrate resources and clinical expertise.[3,10] Small low complexity ICUs are increasingly being transferred and consolidated within regional or tertiary referral ICUs. As a result the available resources and expertise are better utilised, adequate patient volumes and improved access to definitive critical care is achieved.[11]

In hospitals with multiple ICUs, traditionally organised as segregated clinical units operating in isolation, services are increasingly being consolidated into large capacity multi-specialty ICUs referred to as an ICU 'hot-floor'.[12] The principal advantages include concentration of resources, a larger and more flexible ICU bed capacity, standardisation of clinical practice, efficiencies through economy of scale and enhanced operational synergies across critical care sub-specialities.[13,14] Predictions of future service provision suggest that ICUs will comprise a much larger proportion of acute hospital beds, increasing from three to five per cent currently to between twenty and thirty per cent of beds.[3]

The association between large capacity high patient volume ICUs and mortality, however, is not well understood and the evidence to date is inconsistent across diagnostic groups. Early studies, conducted across a range of countries in the US, UK and Europe, suggested that critically ill patients have better outcomes in high volume ICUs with a reasonable occupancy rate.[15–18] In 1999 it was observed that larger units reduced average costs through increased economies of scale and also improved patient outcomes by increasing average volumes of activity by clinicians.[19] It was pointed out, however, that there can be no general presumption that larger units produce better outcomes for patients and results of early studies may have suffered from confounding due to heterogeneity of the ICU population.[20]

A recent systematic review of thirteen studies to 2010 concluded that outcomes of specific subsets of ICU patients are better in high volume ICUs.[21] Meta-analysis was not possible due to the heterogeneity of the ICU population and variation in the volume definitions adopted by investigators. The findings conflicted with some earlier studies and were later refuted in a study of mechanically ventilated patients.[22] The studies highlighted the inconsistent association that exists between ICU volume and patient mortality. Conflicting study outcomes, non-linearity of the association observed in some studies, and new studies recently conducted in Finland, United Kingdom, Australia and the United States warrant further contemporary review of the available literature.

Aim

The aim of this integrative literature review was to report on the association between patient volume and risk adjusted mortality in adult ICUs, explore the non-linearity of association and seeks to identify an optimal volume–mortality threshold.

Design

The integrative review strategy included a range of research designs and methods in experimental, non-experimental, qualitative and quantitative studies. This broad perspective enriches the understanding of outcomes measurement through the application of a systematic synthesis to draw conclusions.[23]

Search methods

Electronic databases EMBASE, PubMed and CINAHL were searched using key words: intensive care, critical care, volume, outcome, quality and mortality. Three defined concepts were intersected using Boolean operators: Concept A – terms related to intensive care ('intensive care unit' OR 'ICU' OR 'critical care'); Concept B – terms related to the size of the ICU in regard to workload ('volume' OR 'activity'); and Concept C – terms related to quality of care ('outcome' OR 'mortality' OR 'quality'). Mortality was the specific outcome of interest and 'quality' was included to capture those publications where quality of care was the descriptor of the dependant variable. These concepts were then combined using the Boolean term 'AND' to capture relevant studies.

Previous reviews of the volume–mortality association found limited primary studies undertaken in ICU. Therefore the search was intentionally broad and included all available studies published in English from 1995 to 2012. All study types were considered including cross sectional, cohort studies, case–control and randomised control trials. Reference lists from retained publications were manually searched and additional studies identified.

Inclusion criteria required that studies were: (1) conducted in ICU; (2) involved only adult ICU patients; (3) studied patient mortality against volume; and (4) included risk adjustment of the patient population to control for potential confounding. Studies were excluded if not available in English, consisted of a review or editorial or studied paediatric and/or neonatal populations. Elective procedural sub-populations were also excluded due to pre-operative anaesthetic screening for suitability to undergo surgery and post-operative admission to ICU.

Data abstraction

A data abstraction template was used by the principal investigator to record text and empirical results that related to key concepts of interest in this review. Two associate investigators independently verified the results summarised in Table 1.

Synthesis

Exploration of key concepts, and interdependencies, related to patient volume, volume definitions, ICU case-mix, risk adjustment and risk adjusted mortality was undertaken. Methodological quality and statistical significance was then assessed to determine validity and generalisability of study results in Table 1.

Quality appraisal

The integrative review methodology employed here does not support the application of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for quality appraisal.[24] The lack of a standard definition for volume also prevents the use of PRISMA in this review.[25,26] Study methodology was therefore appraised using the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.[27] STROBE encompasses twenty-two criteria to specifically appraise reports on observational and cross-sectional studies.

Table 1
Study characteristics.

Study	Design	Patient population	Study sample	No. ICUs	Risk adjusted	Volume definition	Outcome	Stat	95% CI/SD	Signific.
Vaara et al. (2012), Finland[41]	Retrospective observational mutlicentre	ICU patients receiving RRT	1558	23	Pt. demographics, diagnostics, TISS, SAPSII, readmission, ICU type, level, size	Annual case volume of RRT patients per ICU	Hospital mortality:			
							Small vs. large ICU	OR 2.061	1.50–2.84	$p<0.001$
							Low vs. high volume	OR 1.594	1.15–2.21	$p<0.005$
							Med. vs. high volume	OR 1.377	1.03–1.84	$p<0.030$
Shahin and Harrison (2012), UK[26]	Retrospective observational mutlicentre	Patients with severe sepsis	30,727	170	Pt. demographics, diagnostics, APACHE II, readmissions, ICU type, level, size	No. admissions with severe sepsis per unit per year	Hospital mortality:			
							Non-ventilated	OR 0.91	0.77–1.06	$p=0.48$
							Mechanically ventilated	OR 0.92	0.79–1.07	n/s
								OR 0.92	0.79–1.08	n/s
Moran and Solomon (2012), Australia[33]	Retrospective observational mutlicentre	All ICU admissions	208,810	136	Pt. demographics, diagnostics, APACHE III, admission status readmissions, mortality, ICU type, level, size	Annualised patient volume per ICU	Hospital mortality per volume decile. Results comparing first decile with last significant	OR 1.26	1.060–1.50	$p=0.009$
Cooke et al. (2012), US[34]	Retrospective observational mutlicentre	All ventilated non-surgical patients	5131	119	Pt. demographics, diagnostics, VA prognositc score, APACHE III, ICU type, level, size	No. admissions with mechanical ventilation (1 year)	30-day mortality, 50-patient increase in volume associated with a 2% decrease in odds of mortality	OR 0.98	0.87–1.10	n/s
Gopal et al. (2011), UK[22]	Retrospective observational mutlicentre	All ventilated patients	17,132	14	Pt. demographics, diagnostics, LOS, APACHE III, admission status, ICU type, level, size	Mean no. ventilated patients per ICU	Mortality folowing 24 h or more ventilation	OR 1.11	0.91–1.35	$p=0.297$ n/s
Reinikainen et al. (2010), Finland[37]	Retrospective observational mutlicentre	Patients with severe sepsis	452	24	Pt. demographics, diagnostics, TISS, SAPSII, mortality, ICU type, level, size	No. ICU beds	ICU, hospital and 1 year mortality	OR 2.36 (inverse)	1.19–4.68	$p=0.014$
Darmon et al. (2010), France[35]	Retrospective observational mutlicentre	All ventilated patients	179,197	294	Pt. demographics, diagnostics, SAPSII, admission source, mortality, LOS	No. ventilated patients annually per hospital	Hospital mortality	OR 0.998	0.998–0.999	$p=0.0001$
Metnitz et al. (2009), Austria[32]	Prospective observational mutlicentre	All ICU admissions	83,259	169	Pt. demographics, diagnostics, TISS28, SAPSII, mortality, LOS, ICU activity	Admissions per bed and diagnoses per bed annually	Hospital mortality	OR 0.97	0.96–0.98	<0.05
Carr et al. (2009), US[40]	Retrospective observational mutlicentre	Post cardiac arrest admit to ICU	4764	39	Pt. demographics, diagnostics, APACHEIII, admission source, LOS, mortality, ICU type, level, activity	Cardiac arrest admissions annually	Hospital mortality:			
							<20	OR 1.00	Not stated	n/s
							20–34	OR 0.78	0.55–1.11	n/s
							35–50	OR 0.71	0.45–1.11	n/s
							>50	OR 0.62	0.45–0.86	<0.01

Table 1 (*Continued*)

Study	Design	Patient population	Study sample	No. ICUs	Risk adjusted	Volume definition	Outcome	Stat	95% CI/SD	Signific.
Kahn et al. (2008), US[8]	Retrospective observational mutlicentre	All ventilated medical patients	180,976	1170	Pt. demographics, diagnostics, Charlson morbidity index, LOS, mortality, ICU type, activity	Annual admissions per ICU (1 year)	In hospital mortality	OR 0.77	Not stated	p = 0.03
Lin et al. (2008), Taiwan[39]	Retrospective observational mutlicentre	Ventilated haematology patients	87,479	n/s	Pt. demographics, diagnostics, Charlson Index, LOS, mortality, ICU type, activity	Mean case load by ICU physician	Hospital mortality (low vol-ume = decreased survival)	OR 0.49	0.45–0.53	p < 0.001
Lecuyer et al. (2008), US[38]	Retrospective observational mutlicentre	Ventilated haematology patients	1753	28	Pt. demographics, diagnostics, SAPSII, LOS, mortality, ICU type, activity	Annual number of haematology patients per unit	ICU mortality	OR 0.98	0.97–0.99	p = 0.002
Peelen et al. (2007), Netherlands[18]	Retrospective observational mutlicentre	Patients with severe sepsis	4605	28	Pt. demographics, diagnostics, APACHE II, SAPSII, SIRS, readmissions, mortality	Annual number of patients with sepsis	ICU and hospital mortality	OR 0.997	0.955–1.0	<0.05
Needham et al. (2006), Canada[43]	Retrospective observational mutlicentre	All ventilated admissions	20,219	126	Pt. demographics, diagnostics, Charlson Index, admission source, mortality, ICU type, activity	Mean number of ventilation epsiodes per hospital	30-Day mortality: Medical patients Surgical patients	 OR 0.94 OR 1.01	 0.90–0.99 0.92–1.11	 <0.05 n/s
Kahn et al. (2006), US[17]	Prospective observational mutlicentre	All ventilated medical ICU admissions	20,241	83	Pt. demographics, diagnostic, APACHEIII, readmission, mortality, ICU/hospital type, size, activity	Total hospital patients annually	ICU and hospital mortality	OR 0.66	0.52–0.83	<0.05
Glance et al. (2006), US[16]	Retrospective observational mutlicentre	All ICU admissions	70,757	92	Pt. demographics, diagnostic, SAPSII, readmission, mortality, ICU type, size, activity	All patient admitted annually	Hospital mortality: All patients Severely ill	 n/s OR 0.77	 Not stated Not stated	 n/s <0.05
Durairaj et al. (2005), US[15]	Retrospective observational mutlicentre	Medical ICU admissions	43,635	44	Pt. demographics, diagnostics, APACHEIII, admission source, LOS, mortality, ICU type, activity	Low, medium and high volume ICUs	Hospital mortality: All patients GI patients Respiratory patients	 HR 0.68 HR 0.77	 0.54–0.85 0.59–0.99	 n/s <0.05 <0.05
Iapichino et al. (2004), Europe[30]	Prospective observational mutlicentre	All ICU admissions	12,615	89	Pt. demographics, diagnostics, SAPSII, admission source, LOS, mortality, ICU type, activity	No. of patients per bed per year	Hospital mortality	OR 0.97	0.95–0.99	<0.05
Jones and Rowan (1995), UK[31]	Retrospective observational mutlicentre	All ICU admissions	8796	26	Pt. demographics, diagnostics, APACHEII, admission source, LOS, mortality, ICU type, activity	Total patients admitted per unit/total days for study period = average daily volume	Hospital mortality: Non-surgical Surgical	 OR −0.33 OR −0.51	 −0.64 to −0.07 −0.75 to −0.15	 n/s n/s

Abbreviations: Pt.: patient; RRT: renal replacement therapy; TISS: Therapeutic Intervention Scoring System; SAPS: Simplified Acute Physiology Score; LOS: length of stay; APACHE: Acute Physiology and Chronic Health Evaluation (score); CI: confidence interval; SD: standard deviation; OR: odds ratio; HR: Hazard Ratio; n/s: not significant.

Results

Search outcome

A total of 94 studies were retained from the initial search with 72 excluded following abstract review. Of the remaining 22 articles a further two studies were excluded due to one study being on the impact of ICU occupancy and the other a study of patient outcomes related to the intensity of care received in closed vs. open medical staffing models.[28,29] Twenty studies in total were retained as described in Fig. 1.

The studies reported on a combined total of 1,012,783 patients in 2843 ICUs from a broad range of countries including the United States, United Kingdom, France, Austria, Finland, Taiwan, Canada, The Netherlands and Australia. All were large observational quantitative multicentre studies conducted at a national or international level.

Three studies were prospective and the remaining seventeen were retrospective cross sectional cohort studies. Five studies were conducted on all consecutive ICU admissions,[16,30–33] seven studied solely ventilated patients,[8,17,22,34–36] three studied patients with severe sepsis[18,26,37] and two studied critically ill haematology patients.[38,39] Also included was one study each on all medical patients, patients post cardiac arrest and patients receiving renal replacement therapy as summarised in Table 1.[15,40,41]

Study quality

In summary, all studies were multicentre with large sample sizes conducted at a national or international level across a broad range of countries. Electronic clinical registries and administrative databases were used with the study design, setting, participant eligibility criteria and variables measured clearly defined.

A majority of studies were retrospective observational studies inferring that there may be a risk of potential confounding and the inclusion of consecutive ICU admissions in a majority of the studies may have introduced recruitment bias. However, while sample size calculations were not described, potential study limitations were countered by large samples sizes ranging from 452 to 208,810 patients, multicentre design, matching of ICU service levels and the application of risk adjustment control measures. Variation in volume definition, time that mortality was measured, patient heterogeneity and differing study methods prevented a formal meta-analysis from being undertaken.

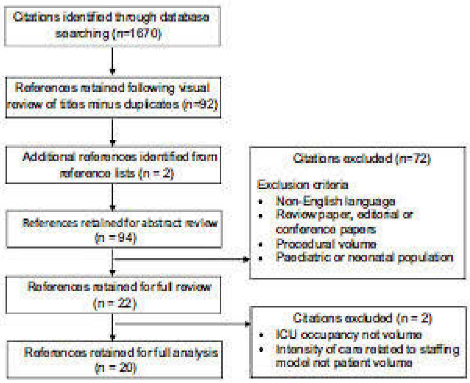


Fig. 1. Flow diagram of study selection strategy.

Patient heterogeneity requires control for severity of illness, diagnosis, age and gender to ensure reported mortality outcomes account for the risk profile of different patient cohorts to minimise confounding and increase generalisability of results.[42] All studies applied risk adjustment to the study population then used multiple logistic regression models to generate adjusted mortality in relation to volume. All studies stratified patients according to demographic characteristics, diagnosis and admission source, including readmission to ICU to further control for sample variation. At the organisational level ICUs were stratified in relation to academic affiliation, service level and complexity, size (number of beds), activity, and in a majority of studies rural vs. metropolitan locations.

Three studies estimated the intensity of the care being provided using the Therapeutic Intervention Scoring System (TISS28) to improve comparators. The Simplified Acute Physiology Score (SAPSII) was used in eight studies, Acute Physiology and Chronic Health Evaluation (APACHE) II and III in eight studies, and the Charlson Morbidity Index in four studies to control for severity of illness and estimate probability of mortality.

Results reported both unadjusted estimates and confounder adjusted estimates with precision of the estimate indicated with confidence intervals. Study limitations were reported and the generalisability of results was clearly established.

Mortality outcome

The definition of mortality as the primary outcome measure varied considerably encompassing mortality occurring in ICU, hospital mortality, 30-day mortality and mortality at one year. Despite the different mortality definitions used, sixteen of the twenty studies reported a significant association, though not uniformly, across all patient sub-groups. High risk, complex and mechanically ventilated patients demonstrated the greatest mortality benefit in high volume ICUs.

A majority of the studies revealed the odds of death to be less than one for higher volume ICUs and an inverse association between volume and mortality for smaller volumes. One study reported a significant mortality risk reduction in all medical ventilated patients of 3.4% ($p = 0.04$) and another reported that high-volume hospitals had lower mortality, relative to low-volume hospitals, among sicker patients (APACHE III score > 57) in the respiratory cohort (Hazard Ratio, 0.77; 95% CI 0.59–0.99) and the GI cohort (Hazard Ratio, 0.67; 95% CI 0.53–0.85).[15,36]

Adjusted mortality rates remained lower in higher volume centres in three studies of all consecutive severely ill ICU admissions undertaken by Glance et al. (OR 0.77, 95% CI not stated, $p < 0.05$), Iapichino et al. (OR 0.97, 95% CI 0.95–0.99; $p < 0.05$) and Metnitz et al. (OR 0.97, 95% CI 0.96–0.98; $p < 0.05$).[16,30,32]

Reduced mortality was repeatedly demonstrated in high volume centres for ventilated medical patients.[8,17,35,36,43] These results were refuted, however, in a more recent Australian study of 208,810 ventilated patients which found no progressive decline in mortality across an annual volume range from 12 to 932 patients.[33] The mortality odds ratio was however significantly higher between the last volume decile (801–932 patients) in the series (OR 1.26, 95% CI 1.06–1.50; $p = 0.009$) and the first volume decile (12–101 patients) (OR 1.053, 95% CI 0.94–1.179; $p = 0.374$).[33]

An association between high patient volumes and mortality was reported for haematology patients in two studies with reduced mortality odds ratios (OR 0.98, 95% CI 0.97–0.99; $p = 0.002$) and (OR 0.49, 95% CI 0.45–0.53; $p < 0.001$).[38,39] Patients with severe sepsis were also found to benefit in two studies demonstrating decreased mortality with increased volume (OR 0.997, 95% CI 0.955–1.0; $p < 0.05$) and inversely with increased mortality associated with decreased volume (OR 2.36, 95% CI 1.19–4.68; $p = 0.014$).[18,37] While one study found a mortality benefit where there was greater than fifty post cardiac arrest admissions to ICU annually (OR 0.62, 95% CI 0.45–0.86; $p < 0.01$).[40] Higher mortality was also observed in patients on continuous renal replacement therapy in low volume ICUs (OR 1.594, 95% CI 1.15–2.21; $p < 0.005$).[41]

Results were mixed across patient sub-groups within individual studies. While medical ICU admissions, for example, were observed to have reduced mortality (OR 0.94, 95% CI 0.90–0.99; $p < 0.05$) surgical admissions did not demonstrate a significant reduction in mortality (OR 1.01, 95% CI 0.92–1.11).[43] Increased severity of illness was a typical characteristic of patient sub-groups with reduced mortality and higher patient volumes.

Lastly, there were four studies which initially observed a significant association between volume and mortality across all patients admitted to ICU.[22,26,31,34] Following risk adjustment, however, the association was no longer significant. This may have been attributable to patient heterogeneity and the use of administrative datasets.

Discussion

Since the late 1970s measuring and understanding the association between volume and patient outcomes in the delivery of health services has been the focus of much research. An early seminal study undertaken in 1979 concluded that higher volumes of procedures should be pursued through regionalisation of services into high volume services.[44] Progressively this principle has been adopted within the ICU environment, resulting in the consolidation of services to achieve a critical mass of patients to improve quality of care, efficiency and ultimately reduce associated service costs.[3,12]

Large consolidated ICUs with high patient volumes typically manage the most complex and severely ill patients. In these ICUs mortality may be reduced by volume in some patient sub-groups.[12] While mortality is the primary outcome of interest it is worth noting that secondary exposures have also been found to have an inverse association with mortality including the presence of intensive care specialists and nurse to patient ratios in the ICU.[17,18,32]

Interpreting the association is complicated by various definitions of volume used including annual volume per ICU, average annual volume, average daily volume, annual volume per bed, diagnostic volume and average case load by physician. Despite this lack of consistency significant volume–mortality associations were found across the range of volume definitions applied in the studies. The validity of associations observed across studies with different volume definitions is supported by a study undertaken in 2009 of 246,051 patients in 268 hospitals over a thirteen-year period which concluded that volume–outcome analysis is similar regardless of how volume is defined.[45]

It was evident from this review that critically ill patients are best managed in ICUs where the most complex, high risk and severely ill patients are concentrated for treatment. This observation is based on the higher severity of illness observed in high volume ICUs and lower mortality.[15,16,30,33] The assumption that high risk ventilated and/or complex patients are best managed in high volume ICUs underpins the requirement for consolidated larger ICUs with sophisticated infrastructure, technology, clinical support services and expertise.[16,17,38] This is reflected in the criteria used to stratify and classify the level of an ICU according to internal resources, infrastructure, organisational model and the level, and availability, of support services such as medical imaging and pathology to support the management of complex critically ill patients.[46,47]

One factor that may explain improved patient outcomes is the impact on the caseload of medical staff. In a large retrospective study involving over 87,000 ICU patients suffering from pneumonia, the mortality of patients managed by high volume ICU physicians was found to be half that observed in low volume ICU physicians (OR 0.49; 95% CI 0.45–053; $p < 0.001$).[39] This is attributed to increased physician experience, enhanced clinical training and the adoption of evidence based standardised clinical practice in an environment with concentrated resources and systematised organisational processes.[8,48]

The association between low volume ICUs and worsening mortality may reflect smaller ICUs not having the same level of access to sophisticated technologies and expertise thereby compounding mortality rates.[16] Smaller ICUs have also been shown, in general, to have a longer average length of stay per patient when compared to high volume ICUs.[37] Baseline staffing levels and infrastructure are required for safe delivery of care. Based on the cost of an average ICU bed day it might be concluded that low volume ICUs are less cost effective than high volume ICUs when considering patient throughput.

While this review found a statistically significant association between higher volume ICUs and improved mortality, in some patient sub-groups, it is important to consider all organisational characteristics of the ICU when interpreting study outcomes. In particular, the presence of a High Dependency Unit (HDU) was significantly associated with higher mortality within a hospital (OR 1.261; 95% CI 0.990–1.680; $p = 0.006$).[18] An HDU provides a step down service for ICU and caters for critically ill patients with lower complexity and risk that do not require a 1 patient to 1 nurse ratio.[54] While there is no explanation for this association it could be due to a higher level of patient severity requiring transitional care in a HDU or due to the emergence of non-invasive ventilation allowing more complex critically ill patients to be managed in non-ICU areas such as HDU.

Higher risk adjusted mortality has been observed in ICUs with medical cover provided by intensive care medical trainees (OR 1.43; $p = 0.000$).[16] While no explanation is forthcoming it could be proposed that intensive care medical trainees work in university accredited tertiary ICUs which attract more complex patients through clinical referral networks. This may infer that a critical mass of severely ill and complex patients is required to support intensive care medical training programmes.

Increased mortality was also observed to be associated with high occupancy (OR 1.324; 95% CI 1.133–1.548; $p < 0.05$).[30] While this appears to counter the high volume-low mortality theory, it instead relates to the intensity of care, or number of beds in an ICU occupied by patients, at any one time impacting on staffing, resources and infrastructure. High volume rather refers to the number of consecutive patients through an ICU bed over a defined period.

Of note is the prospective study of 83,259 consecutive admissions across 169 ICUs which concluded there is a significant association between ICU volume and risk adjusted mortality (OR 0.96, 95% CI 0.956–0.979; $p < 0.05$). Specifically the study found that higher volume was associated with reduced mortality and higher patient to nurse ratio was associated with higher mortality.[32]

A non-linear 'U' shaped correlation has also been observed indicating there may be a low and high volume threshold suggesting a window of optimal organisational performance.[26,32,33] While risk-adjusted mortality may decrease in patients within the same diagnostic category as volume increases, it has also been observed that after a certain annual volume is reached ($n = 450$ cases) there is no further mortality benefit.[32] This non-linearity was also observed in a study of 30,727 patients across all patient sub-groups in 170 ICUs in the United Kingdom, however, no upper volume threshold was specified.[26] An Australian study identified a high volume threshold of 711 patients (OR 0.84; 95% CI, 0.76–0.92) after which no improvements in mortality were observed.[33] While there may be no benefit to mortality observed above a certain volume threshold there may be secondary detrimental effects associated with organisational fatigue.[32] In particular increased medical and nursing workload has been reported repeatedly to be associated with worse outcomes.[32,49,50] Explanations for this include less time for each patient, fewer hygienic measures, more infections, and increased adverse events as care processes break down.

Regionalisation of ICU services is resulting in the emergence of large capacity multi-specialty hot-floor ICUs with typically high patient volumes.[48,27] The high volume threshold suggested in some studies highlights the need to closely consider structural factors of these organisations particularly around staffing models to manage workload. Though under pressure to contain costs, nurse to patient ratios remain relatively constant in ICU. There is, however, a risk that patient to senior ICU Doctor ratios in ICU may not keep pace with growth in capacity and patient volume, and is further compounded by the increasing complexity of critically ill patients.[51–53]

Conclusion

It is evident that there is an association between the volume of patient sub-groups treated in ICU and risk adjusted mortality. Studies suggest patients with higher severity of illness benefit most. A lack of consistent findings across different patient types suggests other factors need to be considered in addition to volume, in particular structural characteristics of the organisation such as staffing models.

The relationship between volume and mortality is not entirely linear with low and high thresholds observed at which the volume mortality relationship reverses. This observation is central to understanding the impact of alternative ICU organisational models on patient outcomes and infers that bigger ICUs may be better but only to a volume threshold. Prospective studies are required to explore this phenomenon further to inform future health policy and capital planning for new and redeveloped intensive care services.

Limitations

This review was limited by varying definitions of volume and the timeframes applied to patient mortality measures, however, it was possible to describe the volume–mortality association that exists in ICUs with different levels of clinical activity. A further limitation was related to a majority of studies being retrospective thereby limiting the ability to control for confounding in the ICU population which has a high heterogeneity. Furthermore the pooling of different ICU patient sub-groups studied may confound results.

Authors' contributions

Brett Abbenbroek initiated the conception and design of the study, and prepared the first draft version of the document. Christine M. Duffield and Doug Elliott reviewed the design, analysis and interpretation of the data, and approved the final version of the document.

Conflict of interest

No conflict of interest has been declared by the author(s).

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Adhikari N, Rubenfeld G. Worldwide demand for critical care. *Curr Opin Crit Care* 2011;**17**(6):620–5.
2. *Metropolitan Health Plan: Technical Paper 2022*. Melbourne: State Government of Victoria, Department of Health; May 2011, 99 p.
3. Vincent J. Critical care – where have we been and where are we going? *Crit Care* 2013;**17**(Suppl. 1:S2):1–6.
4. Craven D. Preventing ventilator-associated pneumonia in adults: sowing seeds of change. *Chest* 2006;**130**(1):251–60.
5. *Costs of Care Standards 2009/10 (GL2011_007)*. Sydney: New South Wales Department of Health; January 2011, 36 p.
6. Halpern N, Pastores S. Critical care medicine in the United States 2000–2005: an analysis of bed numbers, occupancy rates, payer mix, and costs. *Crit Care Med* 2010;**38**(1):65–71.
7. Welton J, Meyer A, Mandelkehr L, Fakhry S, Jarr S. Outcomes of and resource consumption by high-cost patients in the intensive care unit. *Am J Crit Care* 2002;**11**:467–73.
8. Kahn J, Linde-Zwirble W, Wunsch H, Barnato A, Iwashyna T, Roberts M, et al. Potential value of regionalized intensive care for mechanically ventilated medical patients. *Am J Respir Crit Care Med* 2008;**177**(3):285–91.
9. Nguyen Y, Kahn J, Angus D. Reorganizing adult critical care delivery: the role of regionalization, telemedicine, and community outreach. *Am J Respir Crit Care Med* 2010;**181**(11):1164–9.
10. Roberts D, Clark H, Rock B. Development and implementation of a regional intensive care health service model. *Leadersh Health Serv* 2013;**26**(3):232–6.
11. Nguyen Y, Wunsch H, Angus D. Critical care: the impact of organization and management on outcomes. *Curr Opin Crit Care* 2010;**16**(5):487–92.
12. Rashid M. A decade of adult intensive care unit design: a study of the physical design features of the best-practice examples. *Crit Care Nurs Q* 2006;**29**(4):282–311.
13. Kahn J. Volume, outcome, and the organization of intensive care. *Crit Care* 2007;**11**(3):129–30.
14. Rashid M. Technology and the future of intensive care unit design. *Crit Care Nurs Q* 2011;**34**(4):332–60.
15. Durairaj L, Torner J, Chrischilles E, Vaughan Sarrazin M, Yankey J, Rosenthal G. Hospital volume–outcome relationships among medical admissions to ICU. *Chest* 2005;**128**(3):1682–9.
16. Glance L, Li Y, Osler T, Dick A, Mukamel D. Impact of patient volume on the mortality rate of adult intensive care unit patients. *Crit Care Med* 2006;**34**(7):1925–34.
17. Kahn J, Goss C, Heagerty P, Kramer A, O'Brien C, Rubenfeld G. Hospital volume and the outcomes of mechanical ventilation. *N Engl J Med* 2006;**355**(1):41–50.
18. Peelen L, de Keizer N, Peek N, Scheffer G, van der Voort P, de Jonge E. The influence of volume and intensive care unit organization on hospital mortality in patients admitted with severe sepsis: a retrospective multicentre cohort study. *Crit Care* 2007;**11**(2):1–10.
19. Posnett J. Is bigger better? Concentration in the provision of secondary care. *BMJ* 1999;**319**(7216):1063–5.
20. Reade M, Delaney A, Bailey M, Harrison D, Yealy D, Jones P, et al. Prospective meta-analysis using individual patient data in intensive care medicine. *Intensive Care Med* 2010;**36**:11–21.
21. Kanhere M, Harsh A, Cameron A, Maddern G. Does patient volume affect clinical outcomes in adult intensive care units? *Intensive Care Med* 2012;**38**(5):741–51.
22. Gopal S, O'Brien R, Pooni J. The relationship between hospital volume and mortality following mechanical ventilation in the Intensive Care Unit. *Minerva Anestesiol* 2011;**77**(1):26–32.
23. Whittemore R, Knafl K. The integrative review: updated methodology. *J Adv Nurs* 2005;**52**(5):546–53.
24. Moher D, Liberati J, Tetzlaff A, Altman D. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Phys Ther* 2009;**89**(9):873–80.
25. Christian C, Gustafson M, Betensky R, Daley J, Zinner M. The volume–outcome relationship: don't believe everything you see. *World J Surg* 2005;**29**(10):1241–4.
26. Shahin J, Harrison D. Relation between volume and outcome for patients with severe sepsis in United Kingdom: retrospective cohort study. *BMJ* 2012;**344**(29):33–44.
27. von Elm E, Altman D, Egger M, Pocock S, Gotzsche P, Vandenbroucke J. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting of observational studies. *Internist (Berl)* 2008;**49**(6):688–93.
28. Iwashyna J, Kramer A, Kahn J. Intensive Care Unit occupancy and patient outcomes. *Crit Care Med* 2009;**37**(5):1545–57.
29. Singer J, Kohlwes J, Bent S, Zimmerman L, Eisner M. The impact of a "low-intensity" versus "high-intensity" medical intensive care unit on patient outcomes in critically ill veterans. *Intensive Care Med* 2010;**25**(4):233–9.
30. Iapichino G, Gattinoni L, Radrizzani D, Simini B, Bertolini G, Ferla L, et al. Volume of activity and occupancy rate in intensive care units. Association with mortality. *Intensive Care Med* 2004;**30**(2):290–7.
31. Jones J, Rowan K. Is there a relationship between the volume of work carried out in intensive care and its outcome? *Int J Technol Assess Health Care* 1995;**11**(4):762–9.
32. Metnitz B, Metnitz P, Bauer P, Valentin A. Patient volume affects outcome in critically ill patients. *Wien Klin Wochenschr* 2009;**121**(1/2):34–40.
33. Moran J, Solomon P. Mortality and intensive care volume in ventilated patients from 1995 to 2009 in the Australian and New Zealand binational adult patient intensive care database. *Crit Care Med* 2012;**40**(3):800–12.
34. Cooke C, Kennedy E, Wiitala W, Almenoff P, Sales A, Iwashyna T. Despite variation in volume, Veterans Affairs hospitals show consistent outcomes

among patients with non-postoperative mechanical ventilation. *Crit Care Med* 2012;**40**(9):2569–75.
35. Darmon M, Azoulay E, Fulgencio J, Garrigues B, Gouzes C, Moine P, et al. Procedure volume is one determinant of center effect in mechanically ventilated patients. *Eur Respir J* 2011;**37**(2):364–70.
36. Kahn J, Ten Have T, Iwashyna T. The relationship between hospital volume and mortality in mechanical ventilation: an instrumental variable analysis. *Health Serv Res* 2009;**44**(3):862–9.
37. Reinikainen M, Karlsson S, Varpula T, Parviainen I, Ruokonen E, Varpula M, et al. Are small hospitals with small intensive care units able to treat patients with severe sepsis? *Intensive Care Med* 2010;**36**(4):673–9.
38. Lecuyer L, Chevret S, Guidet B, Aegerter P, Martel P, Schlemmer B, et al. Case volume and mortality in haematological patients with acute respiratory failure. *Eur Respir J* 2008;**32**(3):748–54.
39. Lin H, Xirasagar S, Chen C, Hwang Y. Physician's case volume of intensive care unit pneumonia admissions and in-hospital mortality. *Am J Respir Crit Care Med* 2008;**177**(9):989–94.
40. Carr B, Kahn J, Merchant R, Kramer A, Neumar R. Inter-hospital variability in post-cardiac arrest mortality. *Resuscitation* 2009;**80**(1):30–4.
41. Vaara S, Reinikainen M, Kaukonen K, Pettilä V. Association of ICU size and annual case volume of renal replacement therapy patients with mortality. *Acta Anaesthesiol Scand* 2012;**56**(9):1175–82.
42. Needham D, Dowdy D, Mendez-Tellez R, Herridge M, Pronovost P. Studying outcomes of intensive care unit survivors: measuring exposures and outcomes. *Intensive Care Med* 2005;**31**(9):1153–60.
43. Needham D, Bronskill S, Rothwell D, Sibbald W, Pronovost P, Laupacis A, et al. Hospital volume and mortality for mechanical ventilation of medical and surgical patients: a population-based analysis using administrative data. *Crit Care Med* 2006;**34**(9):2349–54.
44. Luft H, Bunker J, Enthoven C. Should operations be regionalized? *N Engl J Med* 1979;**301**(25):1364–9.
45. Kulkarni G, Laupacis A, Urbach D, Fleshner N, Austin P. Varied definitions of hospital volume did not alter the conclusions of volume–outcome analyses. *J Clin Epidemiol* 2009;**62**(4):400–7.
46. *Minimum standards for intensive care units*. Melbourne, Australia: College of Intensive Care Medicine; 2010, 14 p.
47. *Guide to the role delineation of health services*. 3rd ed. Sydney, Australia: New South Wales Department of Health; 2002, 105 p.
48. Conway R, O'Riordan D, Silke B. Consultant volume, as an outcome determinant, in emergency medical admissions. *QJM* 2013;**106**(9):831–7.
49. Lin F, Chaboyer W, Wallis M. A literature review of organisational, individual and teamwork factors contributing to the ICU discharge process. *Aust Crit Care* 2009;**22**(1):29–43.
50. Pronovost P, Angus D, Dorman T, Robinson K, Dremsizov T, Young T. Physician staffing patterns and clinical outcomes in critically ill patients – a systematic review. *JAMA* 2002;**288**(17):2151–62.
51. Dara S, Afessa B. Intensivist-to-bed ratio. *Chest* 2005;**128**(2):567–72.
52. Kramer A, Higgins T, Zimmerman J. Intensive care unit readmissions in U.S. hospitals: patient characteristics, risk factors, and outcomes. *Crit Care Med* 2012;**40**(1):3–10.
53. Ward N, Afessa B, Kleinpell R, Tisherman S, Ries M, Howell M, et al. Intensivist/patient ratios in closed ICUs: a statement from the Society of Critical Care Medicine taskforce on ICU staffing. *Crit Care Med* 2013;**41**(2):638–45.
54. Valentin A, Ferdinande P. Recommendations on basic requirements for intensive care units: structural and organizational aspects. *Intensive Care Med* 2011;**37**(10):1575–87.

2. Quality management review studies

Author	Year	Country	AE[1]	UE[2]	Vent[3]	VAP[4]	CLABSI[5]	VTEP[6]	CAUTI[7]	SU[8]	PU[9]	PS[10]	SS[11]	GC[12]	PF[13]	Mortality	Access	LoS[14]	Occupancy	Volume	AHD[15]	DD[16]	UR[17]	FTR[18]
Duke et al.	2013	Australia														1								
Kasza et al et al.	2013	Australia														1								
Gabrielle et al.	2013	Brazil	1[1]	1							1				1									
Hulscher et al.	2013	Netherlands	1				1								1									
Ahmed et al.	2013	US	1																					
ACHS	2012	Australia					1	1									1					1	1	
Vander Voort et al.	2012	Netherlands	1	1	1						1			1		1		1	1					
Flaatten et al.	2012	Norway	1		1	1	1				1	1	1			1		1	1	1	1		1	
Scottish ICS	2012	Scotland					1									1					1	1		
Rhodes et al.	2012	UK	1	1		1	1									1			1	1			1	
Whittle et al.	2012	UK					1	1		1						1	1	1			1		1	

Note:
1. Adverse Event
2. Unplanned Extubation
3. Ventilation Duration
4. Ventilator Associated Pneumonia
5. Central Line Associated Blood Stream Infection
6. Venous Thromboembolism Prophylaxis
7. Catheter Associated Urinary Tract Infection
8. Stress Ulcer
9. Pressure Ulcer (Injury)
10. Pain Score
11. Sedation Score
12. Glycaemic Control
13. Patient Falls
14. Length of Stay
15. After-Hours Discharge
16. Discharge Delay
17. Unplanned Readmission
18. Failure to rescue
19. ‘1’ = quality management strategy studied

Quality Management Reviews (cont'd.)

Author	Year	Country	AE	UE	Vent.	VAP	CLABSI	VTEP	CAUTI	SU	PU	PS	SS	GC	PF	Mort.	Access	LoS	Occ.	Vol.	AHD	DD	UR	FTR
Asha et al.	2011	Australia															1							
Morton et al.	2011	Australia			1											1		1						
Langley et al.	2011	Sth. Africa																1						
Blegen et al.	2011	US									1					1								1
Garland et al.	2011	US															1							
Halpern et al.	2011	US																	1					
Hart et al.	2011	US	1								1				1									
Howell et al.	2011	US																	1					
Loan et al.	2011	US	1								1	1			1									
Render et al.	2011	US														1								
Stephens et al.	2011	US															1							
Asha et al.	2011	Australia															1							
Morton et al.	2011	Australia			1											1		1						
Langley et al.	2011	Sth. Africa																1						
Blegen et al.	2011	US									1					1								1
Twigg et al.	2010	Australia	1													1								
Meyer et al.	2010	Canada	1			1		1	1		1					1								1
Braun et al.	2010	Germany		1	1	1	1	1		1	1	1	1	1		1	1	1	1	1		1	1	
Antonelli et al.	2010	Italy												1										
Carpuzzo et al.	2010	Italy															1							
De Vos	2010	Netherlands														1								
Liang et al.	2010	Taiwan	1								1				1			1						
Hariharan et al.	2010	UK														1								

Quality Management Reviews (cont'd.)

Author	Year	Country	AE	UE	Vent.	VAP	CLABSI	VTEP	CAUTI	SU	PU	PS	SS	GC	PF	Mort.	Access	LoS	Occ.	Vol.	AHD	DD	UR	FTR
Dubin et al.	2010	US															1							
Krapohl et al.	2010	US				1	1				1													
Nguyen et al.	2010	US	1			1	1									1								
Penoyer et al.	2010	US		1												1								
Singer et al.	2010	US			1											1								
Alakokko et al.	2009	Finland														1								
Hutchings et al.	2009	UK														1		1					1	
West et al.	2009	UK	1													1								
Glance et al.	2009	US	1													1								
Lott et al.	2009	US														1		1						
Murphy et al.	2009	US														1								
Thornlow et al.	2009	US									1													1
Zimmerman et al.	2009	US																	1					
Willis et al.	2008	Australia						1			1					1		1						
Kiekkas et al.	2008	Greece														1								
Rothen et al.	2008	Switzerland	1									1				1		1		1			1	
Aiken et al.	2008	US														1								1
Cho et al.	2008	US														1								
Hearld et al.	2008	US	1													1								
Love et al.	2008	US	1									1				1		1						
MacDaffitt et al.	2008	US	1												1									
Pronovost et al.	2008	US														1					1	1	1	
Sales et al.	2008	US														1								

Quality Management Reviews (cont'd.)

Author	Year	Country	AE	UE	Vent.	VAP	CLABSI	VTE	CAUTI	SU	PU	PS	SS	GC	PF	Mort.	Access	LoS	Occ.	Vol.	AHD	DD	UR	FTR
Smith et al.	2008	US				1					1				1									
Treggarri et al.	2008	US														1								
Wolf et al.	2008	US	1												1			1						
Bellomo et al.	2007	Australia														1								
Hubert et al.	2007	France														1		1						
De Vos et al.	2007	Netherlands	1	1	1						1			1		1		1	1					
Berenholtz et al.	2007	US				1	1	1																
Kane et al.	2007	US	1	1		1										1		1						1
McMillan et al.	2007	US	1		1	1	1	1		1						1		1						
Nathanson et al.	2007	US														1								
Pyle et al.	2007	US	1	1		1	1	1	1	1	1	1	1	1	1	1		1					1	
Stone et al.	2007	US				1	1		1		1					1								
Truog et al.	2007	US															1							
Norena et al.	2006	Canada														1		1						
Numata et al.	2006	Canada														1								
Tourangeau et al.	2006	Canada														1								
Levin et al.	2006	Israel															1							
Curtis et al.	2006	US	1	1		1	1	1		1						1						1	1	
Hampton et al.	2006	US	1		1			1		1						1		1						
Maurer et al.	2006	US				1	1	1			1					1								
Rivard et al.	2006	Us	1				1	1			1					1		1						1

Quality Management Reviews (cont'd.)

Author	Year	Country	AE	UE	Vent.	VAP	CLABSI	VTE	CAUTI	SU	PU	PS	SS	GC	PF	Mort.	Access	LoS	Occ.	Vol.	AHD	DD	UR	FTR
Stockwell et al.	2006	US	1			1	1	1	1							1								1
Duke et al.	2005	Australia	1	1														1		1	1		1	
Estabrooks et al.	2005	Canada														1								1
Kazanjian et al.	2005	Canada																						1
Terblanche et al.	2005	Canada			1	1	1	1		1		1	1			1	1	1				1	1	
McCloskey et al.	2005	New Zealand	1													1		1						
Flaatten et al.	2005	Norway			1											1		1						
Lankshear et al.	2005	UK	1						1		1					1								1
Afessa et al.	2005	US														1		1					1	
Dimick et al.	2005	US														1								
Donaldson et al.	2005	US									1				1									
Dowdy et al.	2005	US														1		1						
Garland et al.	2005	US	1													1				1				
Hass et al.	2005	US														1		1						
Houser et al.	2005	US						1			1													1
McConnell et al.	2005	US															1							
		TOTAL	31	10	10	16	18	15	5	7	21	7	4	5	10	60	12	28	8	6	5	6	13	11

3. ICU outcomes and unit level measures

Quality Indicator: Unplanned Extubation (UE)									
Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results: Organisational Factor	Outcome Variable	Statistic	95% CI/SD	α
Ismael et al. 2013, Egypt	PCC[1]	67	Yes	ICU (n=1)	Nursing Shift (Night)	Unplanned Extubation	63.64%	n/s	< 0.05
Agamez et al. 2013, Spain	ROS[2]	1133	No	ICU (n=1)	Sedation Management Protocol/Scoring	Unplanned Extubation	1.8%	n/s	< 0.05
Cho et al. 2012, Korea	ROS	118	No	ICU (n=1)	Nursing Shift (Night)	Unplanned Extubation	X^2 = 61.52	n/s	= 0.001
Chen et al. 2012, Taiwan	POS[3]	203	No	ICU (n=2)	Nurse Staff Ratio	Unplanned Extubation	OR 2.26	0.12 - 0.57	= 0.001
Liu et al. 2012, Taiwan	PCS[4]	1358	No	Acute (n=21)	Nurse Workload	Unplanned Extubation	r = 0.028	n/s	= 0.02
Jarachovic et al. 2011, US	PCHS[5]	190	No	ICU (n=1)	Weaning Protocol Compliance	Unplanned Extubation	β = 0.66	n/s	= 0.02
Thille et al. 2011, France	POS	340	Yes	ICU (n=1)	Staff Training (ETT Fixation)	Unplanned Extubation	n/s	n/s	< 0.05
de grout et al. 2011, Netherlands	PCC	370	No	ICU (n=1)	Sedation Management Protocol/Scoring	Unplanned Extubation	OR 15.2	1.96 - 117.89	< 0.01
Change et al. 2011, Taiwan	RCC[6]	42	Yes	ICU (n=11)	Nursing Shift (Night)	Unplanned Extubation	76% vs. 23.8	n/s	= 0.00
Chen et al. 2010, Taiwan	ROS	539	Yes	ICU (n=1)	Weaning Protocol Compliance	Unplanned Extubation ,	OR 2.69	1.59 – 4.58	< 0.001
Curry et al. 2008, US	ROS	31	No	ICU (n=1)	Restraining Protocol	Unplanned Extubation	X^2 = 17.06	n/s	< 0.001
					Nurse Experience (<5yrs)	Unplanned Extubation	X^2 = 20.26	n/s	= 0.002
Chang et al. 2008, Taiwan	RCC	300	No	ICU (n=1)	Restraining Protocol	Unplanned Extubation	X^2 = 21.79	n/s	< 0.001

1. Prospective case control 2. Retrospective observation study 3. Prospective observation study 4. Prospective cohort control study 5. Prospective cohort study 6. Retrospective case control

Quality Indicator: Ventilation Duration (Vent.)									
Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results				
					Organisational Factor	Outcome Variable	Statistic	95% CI/SD	α
van der Veer et al. 2013, Netherlands	CRT[7]	25,552	No	ICU (n=30)	Communication & Training Strategy	Reduced Ventilation Duration	HR 0.94	0.76 – 1.15	> 0.05
White et al. 2011, Australia	POS	1,405	No	ICU (n=2)	Multidisciplinary Team	Reduced Ventilation Duration	$\bar{x}$ -0.83	-1.86 – 0.20	< 0.01
Rose et al. 2011, Canada	PCS	586	No	ICU (n=586)	Nurse Staffing not 1:1	Increased Ventilation Duration (Weaning Failed)	OR 0.4	0.1 – 1.0	< 0.05
Singer et al. 2010, US	RCS	227	Yes	ICU (n=1)	High Intensity ICU	Reduced Ventilation Duration	HR 1.66	1.18 – 2.32	= 0.04

7. Cluster randomized trial

Quality Indicator: Ventilator Associated Pneumonia (VAP)									
Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results				
					Organisational Factor	Outcome Variable	Statistic	95% CI/SD	α
Subramanian et al. 2013, Malaysia	PIS[8]	71	n/a	ICU (n=1)	Education Program	VAP Bundle Compliance Increased	t = 21.41	n/s	<0.001
Lim et al. 2013, Taiwan	RIS[9]	27,125	No	ICU (n=1)	Process Checklist	VAP Reduction Pre Post	$\bar{x}$ = 176 $\bar{x}$ = 56	n/s	< 0.001
Raurell et al. 2012, Spain	RCC	140	No	ICU (n=1)	Education Program	VAP Reduction	68%	n/s	< 0.05
Blot et al. 2011, US	ROS	2585	No	ICU (n=27)	Nurse Staffing Ratio (nurse :patient)	VAP Reduction (1:1) (1:2)	9.35% 25.7%	n/s	= 0.003
Berenholtz et al. 2011, US	PCS	550,800 Vent. Days	No	ICU (n=112)	Safety Program	VAP Reduction	IR 0.51	0.41 – 0.64	< 0.05
DuBose et al. 2010, US	PIS	1,147	Yes	ICU (n=1)	Process Checklist	VAP Reduction	$\bar{x}$ = - 6.65	-9.27 - 4.04	= 0.008
Bingham et al. 2010, US	PIS	100	Yes	ICU (n=1)	Education Program	VAP Incidence (No Change pre / post)	n/s	n/s	n/s
Zaydfudim et al. 2009, US	RIS	1,300	No	ICU (n=1)	Compliance Dashboard	VAP Reduction Pre Post	$\bar{x}$ = 15.2 $\bar{x}$ = 9.3	n/s	= 0.01
Khan et al. 2009, Pakistan	PIS	582	Yes	ICU (n=1)	Education Program	VAP Reduction	28%	n/s	= 0.11
Johnson et al. 2009, US	RIS	805	Yes	ICU (n=1)	Multidisciplinary Rounds	VAP Reduction	32%	n/s	= 0.04
Faruqui et al. 2009, US	ROS	4551	No	ICU (n=1)	Process Checklist	VAP Reduction	71%	n/s	< 0.05
Prospero et al. 2008, Italy	PCC	185	Yes	ICU (n=1)	Infection Control	VAP Reduction	RR 0.61	n/s	= 0.049

8. Prospective intervention study 9. Retrospective interventional study

Quality Indicator: Central Line Associated Bloodstream Infection (CLABSI)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Palomar et al. 2013, Spain	PIS	501,296 CVL Days	No	ICU (n=192)	Safety Program	CLABSI Reduction	RR 50%)	0.39 – 0.63	< 0.001
Hong et al. 2013, US	PIS	104,695 CVL Days	No	ICU (n=17)	Safety Program	CLABSI Reduction	39%	n/s	< 0.05
Cherifi et al. 2013, Belgium	PIS	18,467 CVL Days	No	ICU (n=5)	Safety Program	CLABSI Reduction	IR 0.49	0.24 – 0.98	= 0.043
Marsteller et al. 2012, US	RCT	63,180 CVL Days	Yes	ICU (n=45)	Safety Program	CLABSI Reduction	IR 0.19	0.06 – 0.57	= 0.003
Lin et al. 2012, US	RCC	61,665 CVL Days	No	ICU (n=20)	Safety Program	CLABSI Reduction	61%	n/s	n/s
Richardson et al. 2012, US	PIS	21,180 CVL Days	No	ICU (n=1)	Nurse Leader	CLABSI Reduction	100%	n/s	n/s
Terradas et al. 2011, Spain	PIS	375 CVL Insertions	No	ICU (n=1)	Safety Program	CLABSI Reduction	OR 4.32	1.81 – 10.29	< 0.05
Cherry et al. 2011, US	PIS	813 CVL Insertions	No	ICU (n=1)	Credentialing Program	CLABSI Reduction	35%	n/s	= 0.015
Burrell et al. 2011, Australia	PIS	10,890 CVL Insertions	No	ICU (n=37)	Process Checklist	CLABSI Reduction	RR 0.5	0.4 - 0.8	< 0.004
Yacopetti et al. 2010, Australia	PCC	368 CVL Insertions	No	ICU (n=1)	Procedure Staff	CLABSI Reduction	84%	n/s	= 0.04
Parra et al. 2010, Spain	PIS	22,243 CVL Days	No	ICU (n=3)	Education Program	CLABSI Reduction	30.9%	n/s	= 0.03
Rosenthal et al. 2010, India	PIS	53,719	No	ICU (n=86)	Education & Feedback	CLABSI Reduction	RR 0.46	0.33 – 0.63	< 0.001

Quality Indicator: Central Line Associated Bloodstream Infection (CLABSI)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
DePalo et al. 2010, US	PIS	n/s	No	ICU (n=23)	Safety Program	CLABSI Reduction	74%	n/s	= 0.0032
Peredo et al. 2010, Spain	PCHS	6,868 CVL Days	No	ICU (n=1)	Process Checklist	CLABSI Reduction	RR 36%	0.16 – 0.8	= 0.015
Zack et al. 2008, US	ROS	n/s	No	ICU (n=1)	Nurse Education	CLABSI Reduction	66%	n/s	< 0.01
Kritchevsky et al. 2008, US	POS	2970 Patients	No	ICU (n=50)	Number of ICU beds	CLABSI Incidence (Reduction per Bed)	3%	n/s	< 0.05
Koll et al. 2008, US	RIS	n/s	No	ICU (n=36)	Safety Program	CLABSI Reduction	54%	n/s	< 0.001

Quality Indicator: Venous Thrombo Embolism Prophylaxis (VTEP)									
Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results				
					Organisational Factor	Outcome Variable	Statistic	95% CI/SD	α
Weissman et al. 2013, US	RCHS	277,286	No	ICU (n=155)	ICU Occupancy	VTE Prophylaxis Compliance	OR 0.98	0.97 – 0.98	< 0.05
Kahn et al. 2013, US	ROS	73,343	No	ICU (n=55)	Safety Program (Alert)	VTE Prophylaxis Compliance	RD 13%	0.01 - 0. 25	< 0.05
Duff et al. 2011, Australia	PIS	576 (Staff)	No	ICU (n=1)	Safety Program (Alert)	VTE Prophylaxis Compliance	19%	n/s	= 0.02
Tawfiq et al. 2011, Saudi Arabia	PIS	560	No	ICU (n=1)	Education Program	VTE Prophylaxis Compliance	37%	n/s	= 0.002
Lily et al. 2011, US	PIS	6,290	Yes	ICU (n=7)	Telemedicine	VTE Prophylaxis Compliance	OR 15.4	11.3 – 21.1	< 0.05
Morris et al. 2010, Scotland	PIS	224	No	ICU (n=22)	Pharmacist Review	VTE Prophylaxis Compliance	RR 0.89	0.79 – 0.99	< 0.05
Boddi et al. 2010, Italy	PIS	290	Yes	ICU (n=1)	Education Program	VTE Incidence Reduction	61%	n/s	< 0.01
Dabbagh et al. 2009, US	RCHS	105	No	ICU (n=1)	Junior Staff	VTE Prophylaxis Compliance (Reduced)	82%	n/s	= 0.01

Quality Indicator: Catheter Associated Urinary Tract Infection (CAUTI)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Leblebicioglu et al. 2013, Turkey	PIS	4,231	No	ICU (n=13)	Safety Program	CAUTI Reduction	RR 0.53	0.4 – 0.7	= 0.0001
Navoa-Ng et al. 2013, Argentina	PIS	3,183	No	ICU (n=4)	Safety Program	CAUTI Reduction	RR 0.24	0.11 – 0.53	= 0.0001
Kanj et al. 2013, Lebanon	PIS	1506	No	ICU (n=1)	Safety Program	CAUTI Reduction	RR 0.17	0.06 – 0.5	= 0.002
Conway et al. 2012, US	POS	415 (units)	n/a	ICU (n=415)	Large ICU Size	CAUTI Prevention Strategy Reduced	OR 0.52	0.33 – 0.86	< 0.05
Fuchs et al. 2011, US	PIS	n/s	No	ICU (n=5)	Process Checklist	CAUTI Reduction	49%	n/s	= 0.068
Rosenthal et al. 2012, Germany	PIS	56,429	No	ICU (n=57)	Safety Program	CAUTI Reduction	RR 0.63	0.55 – 0.72	< 0.05

Quality Indicator: Pressure Ulceration (PU)									
Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results				
					Organisational Factor	Outcome Variable	Statistic	95% CI/SD	α
Cramesco et al. 2013, Brazil	POS	160	Yes	ICU (n=1)	Nurse Workload	PU Incidence Reduction	4%	n/s	= 0.148
Kelleher et al. 2012, US	PIS	180	No	ICU (n=1)	Nurse Rounds	PU Incidence Reduction	50%	n/s	n/s
Strand et al. 2010, Sweden	POS	146 (nurses)	n/a	ICU (n=4)	Staff Classification	PU Assessment Reduction	41%	n/s	= 0.019
Saperas et al. 2008, Spain	PIS	480	No	ICU (n=1)	Education Program	PU Incidence Reduction	OR 0.40	0.26 - 0.62	<0.01
Elliott et al. 2008, Australia	ROS	563	Yes	ICU (n=1)	Safety Program	PU Incidence Reduction	83%	n/s	n/s

Quality Indicator: Falls (PF)
No empirical studies specific to ICU. 65 titles initially, external to the ICU environment or post discharge eg. Patman 2011 n=63, 1 alternative nurse resource excluded, 1 qualification related in ICU. Attributed to general ward areas where patients are more readily mobilising independently.

Quality Indicator: Access									
Bisbal et al. 2012, US	ROS	3,540	No	ICU (n=1)	Admission During ICU Ward Rounds	Mortality Increased	HR 1.10	0.94 – 1.28	= 0.24
Howell et al. 2010, US	PIS	1,716	Yes	ICU (n=1)	Hospitalist Managed Bed Flow	Throughput (time in ED)	- 28% (min)	n/s	< 0.0001

Quality Indicator: Length of Stay (LoS)

Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results					
					Organisational Factor	Outcome Variable		Statistic	95% CI/SD	α
Walker et al. 2013, US	ROS	201	Yes	ICU (n=1)	Palliative Care Team	LoS Reduction (Days)		36%	n/s	< 0.001
Kucukarslan et al. 2013, US	RCT	126	Yes	ICU (n=1)	Pharmacist Review	LoS Reduction (Days)		$\bar{x}$ = - 25%	n/s	= 0.34
Kerlin et al. 2013, US	RCT	1598	Yes	ICU (n=1)	Medical Staff (Night)	LoS Reduction		RR 0.98	0.88 – 1.09	= 0.72
Ju et al. 2013, China	ROS	2,891	Yes	ICU (n=1)	Night Admission	LoS Reduction (Hours)		$\bar{x}$ = - 43%	n/s	= 0.011
Zampieri et al. 2013, Brazil	ROS	3,257	Yes	ICU (n=1)	Emergency Admissions	LoS Increased		OR 2.87	1.27 – 6.51	< 0.05
Danckers et al. 2013, US	PCC	102	Yes	ICU (n=1)	Nurse Initiated Protocol (Extubation)	LoS Reduction (Days)		$\tilde{x}$ = - 29%	n/s	= 0.01
Bhama, et al. 2013, US	ROS	102	No	ICU (n=1)	Closed ICU Model	LoS Increased (Hours)		$\bar{x}$ = 3%	n/s	= 0.90
Willmitch et al. 2012, US	RIS	24,656	Yes	ICU (n=10)	Telemedicine	LoS Reduction (Days)		$\bar{x}$ = - 3.8	3.65 – 3.94	< 0.01
Parikh et al. 2012, US	RIS	2,181	Yes	ICU (n=1)	Medical Staffing	LoS Reduction (Days)		$\bar{x}$ = - 23%	n/s	< 0.002
McNelis et al. 2012, US	PIS	2,117	Yes	ICU (n=1)	Telemedicine	LoS Reduction (Days)		$\bar{x}$ = - 54%	n/s	< 0.05
Kubler et al. 2012, Poland	POS	847	Yes	ICU (n=1)	HAI Rate	LoS Increase (Days)	CLABSI	$\bar{x}$ = 3.1	3.2 – 87.7	< 0.05
							VAP	$\bar{x}$ = 8.6	6.4 – 56.9	< 0.05
							CAUTI	$\bar{x}$ = 8.1	4.5 – 132.6	< 0.05
Garland et al. 2012, Canada	PCC	501	Yes	ICU (n=2)	Medical Staffing (Night)	LoS Reduction (Hours)		$\bar{x}$ = - 6	n/s	= 0.46

Quality Indicator: Length of Stay (LoS) cont'd.

Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results					
					Organisational Factor	Outcome Variable		Statistic	95% CI/SD	α
Emlet et al. 2012, US	PIS	820	n/s	ICU (n=1)	Medical Staffing (Night)	LoS Reduction (Days)		$\bar{x}$ = - 32%	n/s	< 0.05
Pacheco et al. 2011, Brazil	PIS	1,600	Yes	ICU (n=1)	Multidisciplinary Rounds	LoS Reduction (Hours)		β = - 0.07	n/s	= 0.01
Lipitz-Snyderman et al. 2011, US	RCC	1,330,484	No	ICU (n=549)	Quality Program	LoS Reduction (Hours)		X^2 = 2.05	n/s	= 0.56
Curtis et al. 2011, US	RCT	2,318	No	ICU (n=12)	Quality Program	LoS Increase (Hours)		HR 0.9	n/s	= 0.07
Banerjee et al. 2011, US	PIS	3,803	Yes	ICU (n=1)	Medical Staffing (Night)	LoS Reduction (Days)		$\bar{x}$ = -23%	n/s	< 0.05
Huang, et al. 2010, Taiwan	ROS	2,598	Yes	ICU (n=1)	Emergency Admissions	LoS Increase (Hours)		OR 1.925	1.46 - 2.54	< 0.05
Cheung et al. 2010, Australia	RCT	20	Yes	ICU (n=1)	Palliative Care Team	LoS Reduction (Days)		$\tilde{x}$ = - 40%	n/s	= 0.97
Zawada et al. 2009, US	PIS	5,146	Yes	ICU (n=3)	Telemedicine	LoS Reduction (Hours)		OR 0.58	n/s	= 0.001
Kumar et al. 2009, Netherlands	RCHS	1,467	Yes	ICU (n=1)	Medical Staffing (Night)	LoS Reduction (Days)		$\tilde{x}$ = - 14%	n/s	< 0.001
Hawari et al. 2009, US	RIS	1,070	Yes	ICU (n=1)	Staffing Intensity	LoS Reduction (Days)	Pre Post	$\bar{x}$ = 4.46 $\bar{x}$ = 2.63	3.19 – 5.33 2.40 – 2.86	< 0.05
Padilha et al. 2008, Brazil	ROS	200	Yes	ICU (n=4)	Nurse Workload	LoS Increase (Days)		$\bar{x}$ = 31%	n/s	= 0.015
Szilagyi et al. 2008, Hungary	RCT	36	Yes	ICU (n=1)	Dedicated Psychologist	LoS Reduction (Days)		$\bar{x}$ = -4.2	n/s	< 0.022

Quality Indicator: Occupancy (Occ.)									
Author	Study Design	Sample (n)	Case Mix Adjusted	Clinical Unit	Organisational and Patient Outcome Measurement Results				
					Organisational Factor	Outcome Variable	Statistic	95% CI/SD	α
Robert et al. 2012, France	PCHS	1,139	Yes	ICU (n=10)	High Occupancy (Admission Refusal)	Increased Mortality Admitted vs. Non admitted (28 days) (60 days)	30.1 - 24.3% 33.3 - 27.2%	n/s n/s	= 0.07 = 0.06
Iwashyna et al. 2009, US	RCHS	200,499	Yes	ICU (n=10)	Peak Occupancy (Short Term)	Mortality	$F_{(4, 9)}$ = 16.39 R^2 = 0.49	n/s	< 0.001
Chrusch et al. 2009, Canada	PCHS	8,693	Yes	ICU (n=1)	Discharge due to Occupancy	ICU Readmission	RR 1.56	1.05 – 2.31	< 0.001
Howie et al. 2008, UK	PCHS	619	No	ICU (n=1)	High Occupancy	HAI Increased (per patient/day) Peak Low	$\bar{x}$ = 0.009 $\bar{x}$ = 0.006	n/s	< 0.05

Quality Indicator: Volume (Detailed analysis available at: Abbenbroek, B., Duffield, C.M. & Elliott, D. 2014, 'The intensive care unit volume–mortality relationship, is bigger better? An integrative literature review', *Australian Critical Care*, vol. 27, no. 4, pp. 157-64)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Vaara et al. 2012, Finland	ROS	1,558	Yes	ICU (n=23)	Annual case volume of renal replacment therapy patients	Hospital mortality: small vs. large ICU low vs. high volume med.vs. high volume	 OR 2.061 OR 1.594 OR 1.377	 1.50-2.84 1.15-2.21 1.03-1.84	 p<0.001 p<0.005 p<0.030
Shahin et al. 2012, UK	ROS	30,727	Yes	ICU (n=170)	No. admissions with severe sepsis per unit per year	Hospital mortality: Non-ventilated Mechanically ventilated	 OR 0.91 OR 0.92	 0.77 - 1.06 0.79 - 1.07	 p=0.48 n/s[1]
Moran et al. 2012, Australia	ROS	208,810	Yes	ICU (n=136)	Annualised patient volume per ICU	Hospital mortality per volume decile. Results comparing first decile with last significant.	OR 1.26	1.060-1.50	p=0.009
Cooke et al. 2012, US	ROS	5,131	Yes	ICU (n=119)	No. admissions with mechanical ventilation (1 year)	30 day mortality	OR 0.98	0.87-1.10	n/s
Gopal et al. 2011, UK	ROS	17,132	Yes	ICU (n=14)	Mean No. ventilated patients per ICU	Mortality folowing 24 hours or more ventilation	OR 1.11	0.91 - 1.35	p=0.297
Reinikainen et al. 2010, Finland	ROS	452	Yes	ICU (n=24)	No. ICU beds	ICU, hospital & 1year mortality	OR 2.36 (Inverse)	1.19-4.68	p=0.014
Darmon et al. 2010, France	ROS	179,197	Yes	ICU (n=294)	No. ventilated patients annually per hospital	Hospital mortality	OR 0.998	0.998-0.999	p=0.0001
Metnitz et al. 2009, Austria	POS	83,259	Yes	ICU (n=169)	Admissions per bed & diagnoses per bed annually	Hospital mortality	OR 0.97*	0.96-0.98	< 0.05
Kahn et al. 2009, US	ROS	30,677	Yes	ICU (n=169)	Ventilated medical pts. < 300 = low > 300 = high	30 day mortality	RR 3.4%	not stated	p=0.04

Quality Indicator: Volume (cont'd.)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Carr et al. 2009, US	ROS	4,764	Yes	ICU (n=39)	Cardian arrest admissions annually	Hospital mortality:			
						<20	OR 1.00	not stated	n/s
						20–34	OR 0.78	0.55-1.11	n/s
						35–50	OR 0.71	0.45-1.11	n/s
						>50	OR 0.62	0.45-0.86	< 0.01
Kahn et al. 2008, US	ROS	180,976	Yes	ICU (n=1,170)	Annual ventilated medical admissions (1 year)	In hospital mortality	OR 0.77	not stated	p = 0.03
Lin et al. 2008, Taiwan	ROS	87,479	Yes	n/s	Mean case load by ICU physician	Hospital mortality (Low volume = decreased survival)	OR 0.49	0.45-0.53	p<0.001
Lecuyer et al. 2008, US	ROS	1,753	Yes	ICU (n=28)	Annual number of haematology patients per unit	ICU mortality	OR 0.98	0.97-0.99	P=0.002
Peelen et al. 2007, Netherlands	POS	4,605	Yes	ICU (n=28)	Annual number of patients with sepsis	ICU and hospital mortality	OR 0.997	0.955-1.0	< 0.05
Kahn et al. 2006, US	POS	20,241	Yes	ICU (n=83)	Total hospital patients annually	ICU and hospital mortality	OR 0.66	0.52.083	< 0.05
Glance et al. 2006, US	ROS	70,757	Yes	ICU (n=92)	All patient admitted annually	Hospital mortality:			
						All patients	n/s	not stated	n/s
						Severelly ill	OR 0.77*	not stated	< 0.05

Quality Indicator: Volume (cont'd.)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Durairaj et al. 2005, US	ROS	43,635	Yes	ICU (n=44)	Low, medium and high volume ICUs	Hospital mortality: All patients GI patients Respiratory patients	 HR 0.68 HR 0.77	 0.54-0.85 0.59-0.99	 n/s <0.05 <0.05
Iapichino et al. 2004, Europe	POS	12,615	Yes	ICU (n=89)	No. of patients per bed per year	Hospital mortality	OR 0.97	0.95-0.99	< 0.05
Jones et al. 1995, UK	ROS	8,796	Yes	ICU (n=26)	Total patients admitted per unit/total days for study period = avg. daily volume.	Hospital mortality	p = 0.37	0.53-0.22	n/s.

Quality Indicator: After-Hours Discharge (AHD)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Ouanes et al. 2012, France	ROS	3,462	Yes	ICU (n=4)	After-Hours Discharge (Night)	Mortality	OR 2.5	1.3 – 4.9	= 0.006
Santamaria et al. 2011, Australia	POS	10,211	Yes	ICU (n=40)	After-Hours Discharge	Mortality	OR 1.47	1.05 – 2.05	< 0.05
Laupland et al. 2011, France	**RCHS**	5,992	Yes	National Database	After-Hours Discharge	Mortality	OR 1.54	1.12 – 2.11	= 0.008
Singh et al. 2010, Australia	ROS	1,871	Yes	ICU (n=1)	After-Hours Discharge	Mortality	OR 1.38	1.01 – 1.88	< 0.05
Gopal et al. 2010, UK	ROS	1,050	Yes	ICU (n=1)	After-Hours Discharge	Readmission	OR 2.75	1.7 – 4.3	< 0.001
Hanane et al. 2008, US	ROS	11,659	Yes	ICU (n=1)	After-Hours Discharge	Readmission	12.2 vs 9.0%	n/s	= 0.027
Laupland et al. 2008, Canada	RCHS	17,864	Yes	National Database	After-Hours Discharge	Mortality	12 vs 5%	n/s	< 0.001

Outcome Measure: Delayed Discharge (DD)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Johnson et al. 2013, US	POS	731	No	ICU (n=1)	Delayed Discharge	After-Hours Discharge	X^2 = 10.6	n/s	< 0.005
Garland et al. 2013, US	POS	2,401	Yes	ICU (n=1)	Delayed Discharge	Mortality (20hours)	OR 0.35	n/s	= 0.002
						(48hours)	OR 0.56		
						(72hours)	OR 0.91		
						(93hours)	OR 1.39		
Williams et al. 2010, Australia	RCHS	1,095	No	ICU (n=1)	Delayed Discharge	Proportion > 8hours	6%	n/s	< 0.001

Outcome Measure: Unplanned Readmission (UR)									
Author	**Study Design**	**Sample (n)**	**Case Mix Adjusted**	**Clinical Unit**	**Organisational and Patient Outcome Measurement Results**				
					Organisational Factor	**Outcome Variable**	**Statistic**	**95% CI/SD**	**α**
Diya et al. 2012, Belgium	ROS	9,052	Yes	ICU (n/s)	Nurse Staffing Level/Patient Volume	Readmission	$\overline{x}$ = -0.46	-0.84 : - 0.09	= 0.06
Brown et al. 2012, US	RCHS	192,202	Yes	ICU (n=156)	ICU Level (Tertiary)	Readmission	OR 1.51	1.12 – 2.02	< 0.05
Rodriguez et al. 2011, Spain	POS	1,521	Yes	ICU (n=1)	Readmission Rate	Mortality	OR 3.46	1.76 – 6.78	< 0.05
					Premature Discharge	Mortality	OR 2.6	1.06 – 4.41	< 0.05
Silva et al. 2011, Brazil	PCHS	600	Yes	ICU (n=4)	Nursing Workload (Discharge score)	Readmission	OR 0.98	0.95 – 1.00	= 0.036
Renton et al. 2011, Australia	ROS	13, 598	Yes	ICU (n=38)	Tertiary Level	Readmission	OR 1.21	1.15 – 1.29	< 0.001
					AH Discharge		OR 1.13	1.08 – 1.19	< 0.001
					Length of Stay		OR 1.017	1.015 – 1.019	< 0.001
Frost et al. 2010, Australia	RCHS	987	No	ICU (n=1)	Length of Stay	Readmission	OR 2.2	1.85 – 2.56	< 0.05
					Emergency Admission	Readmission	OR 1.7	1.44 – 2.08	< 0.05
Utzolino et al. 2010, US	RCHS	2,558	No	ICU (n=1)	Premature vs Elective Discharge	Readmission	8.3 vs 25.1%	n/s	< 0.001
Makris et al. 2010, Australia	RCC	410	Yes	ICU (n=1)	Readmission Rate	Mortality	OR 4.7	2.1 – 10.7	< 0.05
					Weekday Discharge	Readmission	OR 1.9	1.1 – 3.5	< 0.05
Gopal et al. 2010, UK	ROS	1,050	No	ICU (n=1)	After-Hours Discharge	Readmission	OR 2.27	1.7 – 4.3	< 0.001
Chrusch et al. 2009, US	PCC	8,222	Yes	ICU (n=1)	High Occupancy	Readmission	RR 1.56	1.05 – 2.31	< 0.05
Baker et al. 2009, US	RCC	3,233	Yes	ICU (n=1)	High Patient Volume	Readmission	2.34; 95%	1.27 – 4.34	< 0.05

4. Nurse outcome definitions

(Page 1 of 3)

Term	Description
Autonomy	Freedom to make discretionary decisions within the domain of an individual's profession based on comprehensive knowledge, clinical expertise and evidence, and act accordingly (Iliopoulou & While 2010; Papathanassoglou et al. 2012)
Control over practice (independence)	The degree to which nurses make decisions about resource management, coordination and delivery of care, and the ability to solve problems that affect the quality of patient care. Control contributes to a positive practice environment that influences job satisfaction, which in turn is linked to improved patient outcomes (Gasparino, de Brito Guirardello & Aiken 2011; Roche & Duffield 2010).
Empowerment	Workplace empowerment relates to the power to access the structural factors within the work environment that enable the employee to get work done such as to information, resources, support and opportunities. Both formal and informal sources of power exist with formal power derived from the specific role one fills and informally through personal alliances and connections within the work setting. Empowerment may predict work effectiveness, job satisfaction and intent to stay at the individual and team level (Faulkner & Laschinger 2008; Purdy et al. 2010)
Role conflict or ambiguity	Arises from a lack of distinction in the allocation of responsibilities which may lead to role overlap and role conflict within the healthcare team, in turn diminishing professional autonomy and professional rights. Contributing factors include carrying out duties with inadequate resources and staff, receiving incompatible requests from team members, contravening evidence and policy to complete a task, not fully understanding own responsibilities, no clear plan or objectives established for the job at hand, and uncertain of personal authority or autonomy (Iliopoulou & While 2010; Stordeur & D'Hoore 2007).
Nursing foundations	The philosophical, theoretical, experiential and competency elements that underpin safe and high quality nursing care. Key elements required to establish these elements include documented, up-to-date care plans, a clear philosophy of nursing, clinical care delivered on nursing model with demonstrated continuity of care, access to continued education and preceptorship for new nurses. These elements underpin the foundations which support nurses in their role as it empowers them to consult competent colleagues, develop their skills and undertake autonomous care which has been linked to improved nurse and patient outcomes (Aitken et al. 2010; Klopper et al. 2012)
Participation in hospital affairs	Relates to the perceived level of engagement the nurse feels influenced by multiple factors including career development, clinical advancement, access to staff development, opportunities for advancement, opportunity to participate in policy decisions, being consulted on staff and ward issues, self-rostering, sound nursing foundations and access to and visibility of senior nurse management (Aitken et al. 2010; Duffield et al. 2010; Klopper et al. 2012).

Nurse Outcome Definitions (cont'd.)

Term	Description
Effective leadership and management	Relating to the Nurse manager and organisational management demonstrating effectiveness through supervisory support of staff, being receptive and responsive, visible to clinicians, encouraging and acknowledging of staff efforts, practices proactive quality assurance and recognised as autonomous with other executive/management. Strong nursing leadership is seen as enabling clinical nurse autonomy and best practice through clear management structures and nursing representation (Duffield, Diers, et al. 2010; Klopper et al. 2012; Minvielle et al. 2005; Van Bogaert et al. 2009).
Collegiality (Nurse- Doctor)	Multidiscipline communication, interaction and collaboration between nursing staff and medical staff in particular which may be formal and informal social and professional contacts within the job context. Key elements are openness, timeliness, accuracy, and understanding. Collaboration has been identified as a way of redressing the power relationship and supporting nurses' autonomy (Karanikola et al. 2012; Manojlovich, Antonakos & Ronis 2009).
Collegiality (Nurse-Nurse)	Communication, interaction and collaboration between nurses, both formal and informal social and professional in the job context which facilitates nursing processes of care, autonomy, clinical decision making, effective team relationships and aids the integration of evidence into clinical practice (Aitken et al. 2010).
Resourcing and staffing	Relates to having sufficient nursing staff and physical resources to get the work done, provide quality patient care and adequate time with patients. Lack of staff and resources have been linked to job-related burnout, job dissatisfaction, and intention to leave. Higher staffing levels have been linked to decreased rates of negative outcomes for patients and shorter lengths of stay (Neff et al. 2011; Roche & Duffield 2010).
Flexible rostering	Work schedules that are flexible, modifiable and incorporate self-rostering are associated with job dissatisfaction and intent to leave. This relates not only to shift patterns but to staff being permanently allocated to their chosen clinical specialty. Self-rostering also reduces the rostering burden on the nursing manager allows them to be more visible in the clinical setting and allows time for other tasks such as performance management and mentorship (Duffield, Roche, et al. 2010; Klopper et al. 2012; Stone et al. 2006).
Access to professional development	Education and training facilitates increased clinical competency, empowers nurses, promotes confidence and promotes critical approach to nursing care. Engagement in continuous professional development supports the professional autonomy of nurses (Papathanassoglou et al. 2012)
Personal accomplishment	Sense of personal fulfilment and autonomy underpinned by formal and informal empowerment. The derived confidence leads to improved collegiality and reduced depersonalisation. Diminished sense of accomplishment is associated with burn out and poor staff outcomes (Gasparino, de Brito Guirardello & Aiken 2011; Minvielle et al. 2005)
Professional advancement	Professional fulfilment and feelings of work-related competence. Associated with perception of professional status independence, participation, opportunities for advancement, educational opportunities and access to study leave, flexibility of the work schedule and wages. Recognition from management is also a key factor in realising professional advancement (Cai & Zhou 2009; Faulkner & Laschinger 2008).

Nurse Outcome Definitions (cont'd.)

Term	Description
Professional perception	Perceived status of nursing as a profession and its sense of meaning. Key determinants are educational preparation, empowerment and the organisational climate and culture. Failure to appreciate the importance of ICU nursing work by a unit's interdisciplinary team may affect ICU nurses' professional status and the quality of professional interactions among the members of the team. Ultimately clinical decision-making autonomy is diminished and a poor public image of nurses may be perceived (Papathanassoglou et al. 2012; Stone et al. 2007).
Satisfaction with nursing	Overall satisfaction with nursing as a profession is a manifestation of the composition of relationships between team members in particular with Doctors, good nursing leadership, autonomy and job satisfaction (Duffield, Roche, et al. 2007).
Job satisfaction	Perception of the practice environment influenced by organisational and personal factors. Factors include quality of nursing leadership, collegial relationships, provision of quality care, nurse autonomy and active participation in decision making, and adequate staffing and resources. A positive practice environment is crucial to job satisfaction, retention of nurses and favourable nurse outcomes (Klopper et al. 2012). Importantly policies, procedures and systems need to be designed so that employees are able to meet the organizational objectives and achieve personal satisfaction in their work.
Emotional exhaustion (burnout)	Feeling of 'emptiness' or 'worn-out', disengagement from work and a sense of reduced competence (Meeusen et al. 2011). Emotional exhaustion is inversely associated with job satisfaction, intention to stay, nurse-assessed quality of care on the unit and personal accomplishment (Van Bogaert et al. 2010)
Moral distress and anxiety	Moral distress occurs when clinicians are unable to translate their moral choices into moral action. Limited autonomy and problematic interdisciplinary collaboration may inhibit nurses' ability to apply personal and professional moral reasoning, a situation that may lead to moral distress. Nurses encounter ethical, professional, and patient-care situations that can provoke moral distress and, if not managed, possibly compromise job satisfaction and retention (Papathanassoglou et al. 2012).
Depersonalisation	An individual emotional state manifested as a lack of care for what happens to patients, impersonal interactions, assigning blame to patients for own frustrations, becoming outwardly more callous in interactions and may worry that job is hardening emotionally (Klopper et al. 2012). Significantly inversely associated with hospital management and organisational support (Van Bogaert et al. 2009).
Intention to leave	Intention to leave or resign can be attributed to two key influences i.e. working conditions, such as e.g., wages or staffing policies, and personal reasons such as retirement or career advancement. The question "Do you plan to leave your current position in the coming year?" has been used frequently in studies to assess the practice environment and nursing workforce outcomes (Stone et al. 2006)

5. Manuscript – ICU nurse survey instrument

(Page 1 of 20)

REVIEWS

Selection of an instrument to evaluate the organizational environment of nurses working in intensive care: an integrative review

Brett Abbenbroek, Christine Duffield, Doug Elliott

Centre for Health Services Management, Faculty of Health, University of Technology, Sydney, Australia

Correspondence: Brett Abbenbroek. Address: Centre for Health Services Management, Faculty of Health, University of Technology, Sydney, 15 Broadway Ultimo, NSW 2007, Australia. E-mail: Brett.J.Abbenbroek@student.uts.edu.au

Received: August 18, 2014 **Accepted:** October 16, 2014 **Online Published:** October 31, 2014
DOI: 10.5430/jha.v3n6p143 **URL:** http://dx.doi.org/10.5430/jha.v3n6p143

Abstract

Objective: To determine an appropriate survey instrument to evaluate the impact of organizational structures on the work environment of intensive care nurses.

Background: Internationally the demand for intensive care is increasing. Solely increasing bed capacity is not sustainable. Large capacity multi-specialty Intensive Care Units are emerging as the preferred organizational model with benefits resulting from optimizing operational synergies and economies of scale. The impact of this organizational transition on intensive care nurses is not well understood. An appropriate survey instrument for intensive care nurses is required. Design: Integrative literature review. Data Sources: CINAHL, PubMed, EMBASE and OVID Nursing databases searched for studies published between 2005 and 2013.

Review methods: An integrative review and quality assessment of the studies was undertaken to select nurse outcome measures associated with organizational structures across a range of acute and critical care settings. Congruence between nurse outcome measures and nurse survey instruments tested in the literature was assessed to select instruments for further psychometric evaluation.

Results: Thirty-one cross sectional quantitative studies, from fourteen countries, were reviewed. Twenty one nurse outcome measures associated with organizational factors were identified and a total of twenty five survey instruments used in the studies reviewed. Assessment of congruence and psychometric properties determined that a combination of two instruments is required to comprehensively assess the organizational environment of nurses working in intensive care units.

Conclusion: The environment of nurses working in intensive care is effectively evaluated with an instrument that combines subscales from the Practice Environment Scale-Nurse Work Index and Maslach's Burnout Inventory.

Key words

Nurse, Intensive care, Critical care, Organization, Environment, Outcome, Satisfaction

1 Introduction

Intensive Care Units (ICUs) support critically ill patients that require complex clinical management, sophisticated technologies and high resource inputs. Internationally, the demand for intensive care is growing due to aging populations, higher inpatient acuity with increasing multiple co-morbidities and advanced medical technologies [1, 2].

Effective demand management aims to improve utilization of available bed capacity while optimizing patient and staff outcomes [3]. An established demand management strategy is coordinated networking between hospitals for the referral of critically ill patients to access definitive care [4, 5]. As a result organizational transformation in the form of regionalization, or consolidation, of ICU services is being adopted across clinical networks and within individual hospitals [6].

Large-capacity multi-specialty ICUs are emerging as the preferred organizational model in tertiary and regional referral hospitals where historically multiple sub-specialty ICUs operated separately [2, 4, 7]. Typically these units range from fifty to seventy beds, in contrast to the traditional ICU model of between ten and twelve beds, and require a large clinical workforce [7-9].

Benefits are thought to be linked to consolidation and better utilization of expertise and resources [2, 10]. Flexible patient flow, economies of scale, enhanced operational synergies and standardization of practice underpin the benefits achieved [11-13].

Increasing bed capacity alone is not sustainable, however, in terms of both fiscal and human resources [14, 15]. Structural changes to the work environment are required to achieve organizational transformation and include nursing management models, nurse staffing, rostering, professional development and the need for a large nursing workforce [13].

A major challenge is effective management of the large nurse workforce required on a 24-hour basis, so as to optimize nurse outcomes such as staff satisfaction and retention [16, 17]. Nurse outcomes have been investigated in acute care environments [18, 19], however, intensive care nurse outcomes are not so well understood and may result in the adoption of unsustainable organizational models [20-22]. A survey instrument sensitive to organizational factors and culture, with strong psychometric properties, is required to evaluate the working environment of intensive care nurses, inform managers and promote workforce sustainability in the face of organizational change.

2 Method

An integrative literature review of the empirical literature was conducted using methodological approaches described by Cooper (1982) [23] and Dixon-Woods *et al.* (2004) [24] for integrative reviews of quantitative and qualitative research. An integrative approach includes a diverse range of study designs, if present in the literature, thereby providing a broad perspective that enriches the understanding of the topic [25]. Key review stages included a review of acute care nurse outcome studies, quality assessment, identifying nurse outcome measures and the survey instruments tested, followed by an assessment of the selected instrument psychometric properties.

2.1 Search method

During the literature search stage, the first author interrogated the CINAHL, PubMed, EMBASE and OVID Nursing databases for English language studies published internationally between 2005 and 2013 (December). Early literature from 2005 was included to capture seminal studies by Manojlovich *et al.* (2005) [26] and Stone *et al.* (2006) [3]. The keyword used for the search was "nurse" with advanced searching cross-referencing the search terms "intensive care", "critical care", "ICU", "environment", "organization", "outcome" and "satisfaction".

Studies reviewed were included based on the following criteria: (1) empirical study reports; (2) studies conducted in an acute care environment; (3) explicit study of the association between nurse outcomes and organizational factors; and

(4) psychometric properties of the survey instrument used was defined. Exclusion criteria included: (1) non-English language publications; (2) non-adults; and (3) editorials or unpublished dissertations.

2.2 Search results

The search yielded a total of 309 studies of which thirty nine were initially retained. Further analysis excluded three studies that used either a locally developed non-validated survey instrument tested on a small sample of nurses [27, 28] or focused on nurse-sensitive patient outcomes [29]. Five studies were excluded as they focused solely on validating survey instruments through subscale factor analysis [31-34]. The procedure and outcomes are outlined in Figure 1.

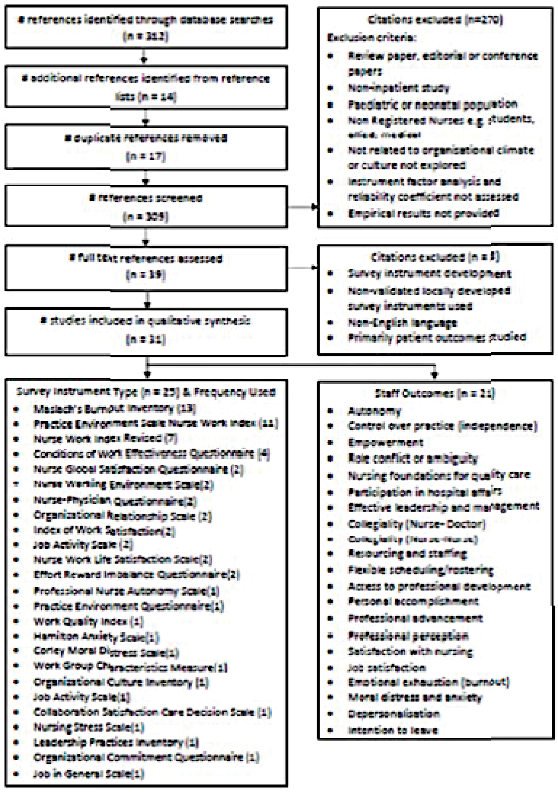


Figure 1. Literature search summary flow chart

Note. Definitions of survey instruments available from the author on request.

Conclusion

Thirty one studies were retained for full analysis as summarized in Table 1. Twenty one nurse outcomes were identified for further exploration. Twenty five survey instruments were used either singularly or in combination as listed in Figure 1. A comprehensive quality appraisal was then undertaken to further validate the inclusion of identified studies in this review.

2.3 Quality appraisal

Quality was assessed based on criteria recommended in the Critical Review of Quantitative Research Worksheet and aligned with the methods promoted in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [35, 36]. Each criteria was assessed using an allocated score based on the evidence hierarchy proposed by Evans (2003) [37]. This scoring process, first developed by Beck (1995) [38] and applied recently to a literature review of nurse turnover costs conducted by Li *et al*. (2012) [39], was adopted and expanded with additional quality criteria proposed by Miller (2006) [35].

Table 1. Literature review result summary

Author	Study Design	Survey Tool	Cronbach α (composite)	Sample (n)	Inpatient Clinical Unit	Workplace Evaluation Results: Outcome	Variable	Stat‡	95% CI/SD	*
Van Bogaert *et al.* 2013, Belgium	PCS† Survey	NWI-R MBI	0.80	1108 RN	Hospital wide acute care (n = 8 hospitals, nursing units = 96)	Job satisfaction	Nurse-Physician collegiality	OR 2.28	1.46-3.54	<0.001
							Nurse management (unit)	OR 10.7	4.97-23.06	<0.001
							Organisational support	OR 9.42	4.23-20.96	<0.001
							Workload	OR 0.35	0.21-0.57	<0.001
							Autonomy	OR 5.27	2.45-11.36	<0.001
							Emotional exhaustion	OR 0.40	0.33-0.49	<0.001
							Depersonalisation	OR 0.55	0.44-0.68	<0.001
							Personal	OR 1.62	1.25-2.12	<0.001
							accomplishment	OR 1.71	1.13-2.59	<0.05
						No intention to leave	Nurse-Physician collegiality	OR 4.10	2.05-8.21	<0.001
							Nurse management (unit)	OR 9.42	2.09-8.53	<0.001
							Organisational support	OR 0.56	0.36-0.87	n/s§
							Workload	OR 1.82	0.93-3.57	n/s
							Autonomy	OR 0.59	0.49-0.71	<0.001
							Emotional exhaustion	OR 0.72	0.58-0.89	<0.001
							Depersonalisation	OR 1.64	1.28-2.12	<0.01
							Personal accomplishment	OR 2.92	1.89-4.51	<0.001
						Quality of care (perceived)	Nurse-Physician collegiality	OR 50.2	19.67-128	<0.001
							Nurse management (unit)	OR 6.87	3.52-14.25	<0.001
							Organisational support	OR 0.77	0.49-1.20	n/s
							Workload	OR 7.03	3.36-14.71	<0.001
							Autonomy	OR 0.68	0.57-0.82	<0.001
							Emotional exhaustion	OR 0.66	0.53-0.82	<0.001
							Depersonalisation	OR 1.48	1.16-1.88	<0.001
Moneke *et al.* 2013, US	PCS† Survey	LPI OCM JIG	0.95 0.86 0.87	112 RN	ICUs (n = 6)	Job satisfaction	Perceived leadership qualities:			
							Modelling the way	r = 0.23	n/a¶	= 0.01
							Inspiring shared vision	r = 0.24	n/a	= 0.01
							Challenging the process	r = 0.23	n/a	= 0.02
							Enabling	r = 0.21	n/a	= 0.02
							Ecouraging the heart	r = 0.13	n/a	= 0.15
							Organisational commitment	β = 0.35	n/a	= 0.00
Myhren *et al.* 2013, Norway	PDC#	MBI	0.70	129 RN	ICUs (n = 3)	Job satisfaction	Emotional exhaustion	r = -0.41	n/a	<0.001
							Depersonalisation	r = -0.31	n/a	<0.001
						Job stress	Personal accomplishment	r = 0.12	n/a	=0.145
							Emotional Exhaustion	r =0.586	n/a	<0.001
							Depersonalisation	r =0.293	n/a	<0.001
							Personal accomplishment	r =0.105	n/a	=0.208
Coetzee *et al.* 2013, South Africa	PCS† Survey	PESWI MBI	0.79 0.88	1187 RN	Hospital wide acute care, (n = 62 hospitals)	Burnout	Practice Environment	OR 0.55	0.41-0.75	= 0.01
							Workload	OR 1.03	0.96-1.10	n/s
						Job dissatisfaction	Practice Environment	OR 0.47	0.34-0.66	= 0.01
							Workload	OR 1.04	0.96-1.13	n/s
						Intent to leave	Practice Environment	OR 0.64	0.49-0.84	= 0.01
							Workload	OR 1.04	0.99-1.10	n/s
						Poor quality	Practice Environment	OR 0.55	0.41-0.74	= 0.01
							Workload	OR 1.06	1.01-1.12	= 0.05
						Poor Management	Practice Environment	OR 0.41	0.31-0.55	= 0.01
							Workload	OR 1.01	0.92-1.12	n/s
						Poor safety	Practice Environment	OR 0.48	0.29-1.02	n/s
							Workload	OR 1.11	1.00-1.24	= 0.05
Aiken *et al.* 2012, Europe & US	PCS† Survey	PES-N WI MBI	Referenced from other studies	EU 33,659	Hospital wide acute care (n = 488EU+ 612US hospitals)	(EU)				
						Poor quality	Practice Environment	OR 0.56	0.51-0.61	< 0.05
						Poor safety	Practice Environment	OR 0.50	0.44-0.56	< 0.05
						Burnout	Practice Environment	OR 0.67	0.61-0.73	< 0.05
						Dissatisfaction	Practice Environment	OR 0.52	0.47-0.57	< 0.05
						Intent to Leave	Practice Environment	OR 0.61	0.56-0.67	< 0.05
						Poor mgmt.	Practice Environment	OR 0.53	0.48-0.58	< 0.05
				US 27,509		(US)				
						Poor quality	Practice Environment	OR 0.54	0.51-0.58	< 0.05
						Poor safety	Practice Environment	OR 0.55	0.50-0.61	< 0.05
						Burnout	Practice Environment	OR 0.71	0.68-0.75	< 0.05
						Dissatisfaction	Practice Environment	OR 0.60	0.57-0.64	< 0.05
						Intent to Leave	Practice Environment	OR 0.69	0.64-0.75	< 0.05
						Poor mgmt.	Practice Environment	OR 0.56	0.54-0.59	< 0.05

(Table continued on page 147)

Table 1. (continued)

Author	Study Design	Survey Tool	Cronbach α (composite)	Sample (n)	Inpatient Clinical Unit	Workplace Evaluation Results				
						Outcome	Variable	Stat[‡]	95% CI/SD	*
Papath-anasso-glou *et al.* 2012, Greece	PDC[#]	CSACD CMDS	0.8 0.8	255 RN	ICUs (n=n/s) Multi-national	Autonomy Moral Distress	Nurse-Physician collegiality Frequency of moral distress Restricted staff development Work satisfaction Independent practice Perceived professional status Intention to resign Nurse-Physician collegiality Nurse patient ratios Perceived professional status Intention to resign	ρ= 0.32 ρ=-0.17 ρ=-0.23 ρ= 0.37 ρ= 0.16 ρ= 0.21 ρ=-0.14 ρ=-0.34 ρ= 0.26 ρ= 0.30 ρ= 0.23	n/a n/a n/a n/a n/a n/a n/a n/a n/a n/a n/a	< 0.001 < 0.04 < 0.001 < 0.001 = 0.005 = 0.001 = 0.03 < 0.001 < 0.001 < 0.001 = 0.01
Karanik-ola *et al.* 2012, Greece	PDC[#]	HAS IWS	0.897 0.83	229 RN	ICU (n = 11)	Anxiety Interaction/ Communicatio n No. ICU beds	Nurse- physician collegiality Nursing collegiality Satisfaction (nurse- physician) Satisfaction (nurse-nurse) Satisfaction nursing collegiality Satisfaction physician collegiality	r = -0.16 r = -0.14 β= -0.09 β= -0.10 r = -0.15 r = -0.21	n/a n/a n/a n/a n/a n/a	= 0.001 = 0.003 = 0.25 = 0.04 = 0.002 < 0.001
Klopper *et al.* 2012, South Africa	PCS[†]	PES-NWI MBI	0.84 0.87	935 RN	ICU (n = 62)	Satisfaction Burnout	Manager leadership Nurse- physician collegiality Staffing and resource adequacy Particpation in hospital affairs Foundations for quality care Governance Professional advancement Leave management Depersonalisation	r = 0.61 r = 0.45 r = 0.33 r = 0.31 r = 0.44 r = 0.39 r = 0.59 r = -0.33 r = -0.58	n/a n/a n/a n/a n/a n/a n/a n/a n/a	< 0.01 < 0.01 < 0.01 < 0.01 < 0.01 < 0.01 < 0.01 < 0.01 < 0.01
Aiken *et al.* 2011, US	PCS[†]	PES-NWI MBI	0.70 n/s	98,116 RN	Hospital wide acute care, (n =1406) global	Positive work environment	Burn out Job disatisfaction	OR 0.54-0.94 OR 0.33-0.72	n/s n/s	< 0.05 < 0.05
Neff *et al.* 2011, US	PCS[†]	PES-NWI	0.84	10,951 Nurses	Hospital wide acute care (national)	Nurse outcomes	Burn out Satisfaction Patient ratio Intent to leave	33.1% 24.4% 5.1:1 18.8%	n/s n/s n/s n/s	<0.0001 <0.0001 <0.0001 <0.0001
Gaspari-no *et al.* 2011, Brazil	PCS[†]	NWI-R	0.95	278 RN	Single Hospital acute care	Autonomy Control own environment Organisational support Nurse-Doctor	Emotional exhaustion Self accomplishment Depersonalisation Intent to leave Intent to leave Intent to leave Intent to leave	r = 0.37 r = 0.30 r = 0.18 r = 0.17 r = 0.22 r = 0.22 r = 0.11	n/s n/s n/s n/s n/s n/s n/s	< 0.01 < 0.01 < 0.05 < 0.05 < 0.05 < 0.05 < 0.05
Meeuse-n *et al.* 2011, Nlands.	PCHS[§]	MBI	0.86	882 Nurses	Anaesth.	Intent to leave	Burnout Job satisfaction	β= 0.24 β= -0.28	n/s n/s	< 0.001 < 0.001
Iliopoul-ou *et al.* 2010, Greece	PCS[†]	PNAS Role Conflict	0.88 0.83	302 RN	ICU (n = 16 units)	Autonomy Role conflict	Job satisfaction Job satisafaction	r = 0.33 r = 0.05	n/s n/s	< 0.001 = 0.4111
Aitken *et al.* 2010, Australia	PCS[†]	PES-NWI NWSS	0.70 0.85	244 RN	ICU (n = 2 units)	Nursing Rounds Pract. Environment	Nurse interaction Participation Nursing foundations Leadership Staffing and resourcing Collegiality (nurse-doctor)	pre 4.85 post 5.36 α = 0.89 α = 0.81 α = 0.71 α = 0.77 α = 0.85	n/s n/s n/s n/s n/s n/s n/s	= 0.002 n/a n/a n/a n/a n/a n/a

(Table continued on page 148)

Table 1. (continued)

Author	Study Design	Survey Tool	Cronbach α (composite)	Sample (n)	Inpatient Clinical Unit	Workplace Evaluation Results: Outcome	Variable	Stat‡	95% CI/SD	*
Purdy *et al.* 2010, Canada	PCHS§	CWEQII WGCM NGSQ	0.86 0.78 0.81	679 RN	Hospital wide acute care (n = 21 hospitals)	Nurse Empowerment	Job satisfaction	r = 0.39	n/s	< 0.001
Roche *et al.* 2010, Australia	2nd analysis of data	PES-NWI	0.82	2556 Nurses	Acute care and mental health (n= 26 hospitals)	Practice environment	Participation Nursing foundations for care Leadership Staffing and resourcing Collegiality (nurse-doctor)	t = 4.68 t = -2.81 t = 4.06 t = -2.02 t = -6.38	n/s n/s n/s n/s n/s	≤ 0.01 ≤ 0.01 ≤ 0.01 = 0.04 ≤ 0.01
Van Bogaert *et al.* 2010, Belgium	PCS†	NWI-R MBI	0.75 0.83	546 RN	Hospital wide acute care (n = 4 hospitals)	Job satisfaction Intention to stay	Collegiality (nurse-doctor) Leadership Organisational support Collegiality (nurse-doctor) Leadership Organisational support	OR 3.94 OR 9.07 OR 17.2 OR 2.26 OR 3.31 OR 4.65	2.90-7.07 3.15-26.2 7.07-72.4 1.23-4.14 0.99-11.2 1.27-17.0	< 0.0001 < 0.0001 < 0.0001 < 0.05 < 0.05 < 0.05
Duffield *et al.* 2010, Australia	2nd analysis of data	NWI-R	0.80	2141 Nurses (1559 RN)	Hospital wide acute care (n = 21 hospitals)	Job satisfaction Intent to leave	Praise and recognition Philosophic foundations Good leadership Flexible rosters Participation Manager visibility Praise and recognition Good leadership	OR 1.47 OR 1.26 OR 1.17 OR 1.16 OR 1.16 OR 1.15 OR 0.83 OR 0.80	1.30-1.67 1.09-1.45 1.03-1.34 1.02-1.30 1.03-1.31 1.03-1.30 0.74-0.94 0.72-0.91	< 0.01 < 0.01 < 0.05 < 0.05 < 0.05 < 0.05 < 0.01 < 0.01
Cai *et al.* 2009, China	PCS†	CWEQII JAS ORS	0.82 0.80 0.89	189 Staff Nurses	Hospital wide acute care (n = 2 hospitals)	Job satisfaction Turnover intention	Empowerment Opportunity Resources Organisational support Empowerment Formal power (JAS)	r = 0.56 r = -0.22 r = -0.30 r = -0.48 r = -0.31 r = -0.27	n/s n/s n/s n/s n/s n/s	= 0.01 = 0.01 = 0.01 = 0.01 = 0.01 = 0.05
Cho *et al.* 2009, South Korea	PCS†	MBI	n/s	1365 RN	ICU (n = 65)	Adequate staffing	Job dissatisfaction Burnout Intent to leave	OR 0.30 OR 0.50 OR 0.40	0.23-0.40 0.34-0.73 0.28-0.56	< 0.05 < 0.05 < 0.05
Gunnarsdottir *Et al.* 2009, Iceland	PCS†	NWI-R MBI	0.77 0.84	695 RN	Hospital wide acute care, (n = 1 hospital)	Job satisfaction Emotional exhaustion	Nurse-Physician relations Unit level support Staffing Philosophy of practice Hospital level support Nurse-Physician relations Unit level support Staffing Philosophy of practice Hospital level support	OR 2.40 OR 6.70 OR 2.23 OR 2.21 OR 2.95 β -2.38 β -3.81 β -3.95 β -2.79 β -2.81	1.59-3.62 4.10-10.9 1.63-3.05 1.47-3.32 1.93-4.52 SE 0.63 SE 0.64 SE 0.47 SE 0.65 SE 0.66	< 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001
Van Bogaert *et al.* 2009, Belgium	PCS†	NWI-R MBI	0.75 0.83	155 RN	Hospital wide acute care (n = 13 hospitals)	Nurse-Doctor colegiality Leadership Organisational support	Job satisfaction Intention to leave Nurse Leadership Personal accomplishment Emotional exhaustion Depersonalisation Job satisfaction Intention to leave Personal accomplishment Emotional exhaustion Depersonalisation Job satisfaction Intention to leave Personal accomplishment Emotional exhaustion Depersonalisation	OR 8.80 OR 5.90 OR 2.90 β 3.20 β -3.70 β -0.90 OR 2.90 OR 1.80 β 3.10 β -3.30 β -1.00 OR 7.60 OR 2.90 β 2.70 β -2.80 β -2.40	2.60-29.6 1.40-25.0 n/s (SE) 0.8 (SE) 1.2 (SE) 0.7 0.90-9.00 1.40-7.60 (SE) 1.1 (SE) 1.6 (SE) 0.9 0.90-65.1 0.30-26.6 (SE 1.0) (SE 1.4) (SE 2.8	< 0.01 < 0.01 < 0.01 < 0.01 < 0.01 n/s n/s n/s < 0.01 < 0.01 n/s n/s n/s < 0.01 < 0.01 < 0.01
Aiken *et al.* 2008, US	PCS†	PES-NWI MBI	0.79 0.92	10,184 RN	Hospital wide acute care (n = 168 hospitals)	Care environemnt Nurse staffing	Burnout Job satisfaction Intent to leave < 1yr Burnout Job satisfaction Intent to leave < 1yr	OR .76 OR 0.75 OR 0.87 OR 1.17 OR 1.11 OR 1.03	0.70-0.82 0.68-0.81 0.79-0.96 1.09-1.25 1.04-1.18 0.95-1.12	< 0.01 < 0.01 < 0.01 < 0.01 < 0.01 < 0.10

(Table continued on page 149)

ISSN 1927-6990 E-ISSN 1927-7008

Table 1. (continued)

Author	Study Design	Survey Tool	Cronbach α (composite)	Sample (n)	Inpatient Clinical Unit	Workplace Evaluation Results				
						Outcome	Variable	Stat‡	95% CI/SD	*
Faulkner *et al.* 2008, Canada	PCS†	CWEQ-II PEQ ERIQ	0.80 0.89 0.77	282 RN	Hospital wide acute care (n = 168 hospitals)	Prof. Respect	Structural empowerment Informal power Support Formal power Resources Information Opportunity Psychological empowerment Autonomy Impact Meaning	$r = 0.47$ $r = 0.44$ $r = 0.38$ $r = 0.34$ $r = 0.32$ $r = 0.30$ $r = 0.24$ $r = 0.32$ $r = 0.31$ $r = 0.25$ $r = 0.22$	n/a n/a n/a n/a n/a n/a n/a n/a n/a n/a n/a	< 0.05 < 0.05 < 0.05 < 0.05 < 0.05 < 0.05 < 0.05 < 0.05 < 0.05 < 0.05 < 0.05
Manojlo-vich *et al.* 2008, US	PCS†	ICU-NPQ	0.85	462 RN	ICU (n= 25 units)	Job satisfaction	Nurse-Doctor communication	$r = 0.34$	n/a	<0.001
Lai *et al.* 2008, Taiwan	PCS†	Locally Developed (Coopers)	0.84	130 RN	ICU (n=2 units)	Intention to leave	Level of happiness Depression Job satisfaction	$\bar{x}$ 2.27 $\bar{x}$ 4.25 $\bar{x}$ 6.75	SD 0.85 SD 1.85 SD 1.61	<0.01 <0.01 <0.01
Stordeur *et al.* 2007, Belgium	PCS†	NEXT NSS COPSOQ ERIQ	0.86 0.74 0.84 0.72	1175 RN	Hospital wide acute care (n = 12 hospitals)	Organisation climate	Schedule/roster flexibility Workload Emotional exhaustion Role ambiguiy Nursing management Nursing team communication Job satisfaction Burnout Intention to leave	$\bar{x}$ 4.2 $\bar{x}$ 3.0 $\bar{x}$ 3.3 $\bar{x}$ 2.2 $\bar{x}$ 2.2 $\bar{x}$ 3.1 $\bar{x}$ 3.8 $\bar{x}$ 3.5 $\bar{x}$ 2.2	n/s n/s n/s n/s n/s n/s n/s n/s n/s	< 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001
Stone *et al.* 2006, US	PCS†	PNWE (NWI-R)	0.78	2323 RN	ICU (n=110 units/66 hospitals)	Intention to leave	Professional practice Nursing management Staffing and resource adequacy Nursing process Nurse-Doctor collegiality Nursing competence Positive scheduling climate Professional practice Nursing management Staffing and resource adequac Nursing process Nurse-Doctor collegiality Nursing competence Positive scheduling climate Bed size (small) Bed size (medium	$\bar{x}$ 2.20 $\bar{x}$ 2.24 $\bar{x}$ 2.77 $\bar{x}$ 2.34 $\bar{x}$ 2.51 $\bar{x}$ 2.92 $\bar{x}$ 2.48 OR 0.52 OR 0.74 OR 1.23 OR 0.81 OR 1.31 OR 0.61 OR 0.81 OR 1.00	SE 0.08 SE 0.08 SE 0.06 SE 0.06 SE 0.06 SE 0.07 SE 0.09 0.42-0.64 0.51-1.08 0.88-1.72 0.54-1.20 0.85-2.03 0.44-0.83 0.60-1.11 0.61-1.63 0.78-1.88	< 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.01 n/s n/s n/s n/s < 0.01 n/s n/s n/s
Manojlo-vich *et al.* 2005, US	PCS†	CWEQ-II PES-NWI IWS	0.90 0.93 0.92	284 RN	Hospital wide acute care (n = n/s) Multi.	Structural empowerment Practice environment Job satisfaction	Nurse-Doctor communcation Job satisfaction Nurse-Doctor communication Job satisfaction Nurse-Doctor communication Structural empowerment	β 0.27 β 0.22 β 0.22 β 0.39 β 0.37 β 0.22	n/s n/s n/s n/s n/s n/s	≤ 0.05 ≤ 0.05 ≤ 0.05 ≤ 0.05 ≤ 0.05 ≤ 0.05
Minviell-e *et al.* 2005, France	PCS†	OCI MBI	> 0.70 > 0.70	1000 (RN = 750)	Hospital wide acute care (n = n/s) Mutli.	Job satisfaction	Participation (affiliation) Empowerment Competence Achievement Self actualising	$r = 0.36$ $r = -0.11$ $r = 0.02$ $r = 0.25$ $r = 0.36$	n/s n/s n/s n/s n/s	<0.001 <0.01 <0.001 <0.001 <0.001

Note. ‡ Statistic legend: * significance; ρ = Pearsons Correlation coefficient; r = sample correlation coefficient; β = regression coefficient; OR = odds ratio; t = t-test; $\bar{X}$ = mean; † PCS = Prospective Cross Sectional Survey; ♦ PDC =Prospective Descriptive Correlation; ǂ PCHS = Prospective Cohort Study; n/a = not applicable; n/s = not specified.

Thirty one criteria were used to derive a quality index score for each study. Potential study bias was assessed using the risk assessment process adapted from a Cochrane Systematic Review undertaken by Inglis *et al.* (2010) [40]. The highest composite score attainable was seventy seven. Each score was then converted to percentages to assess the relative quality for each study (see Figure 2).

The mean quality index score was 85% with minimal variability in the range (75%-91%). Highest scores reflected multicenter studies with a large sample size, clearly defined outcome measures, demonstrated survey instrument validation, high survey response rate, identified complex associations within the results and demonstrated relevance to health services management [41, 42]. Conversely, the lowest scoring study was conducted in a single site with a small convenience sample, and implications for practice were not clearly articulated limiting broader generalization of results [43].

All studies, except one [42], failed to explicitly define the study population exclusion criteria potentially affecting sample selection, with the majority using a convenience sample. While this may limit generalization of results, sample sizes were considered to be moderate to large (range n = 67 to 98,116), mitigating this risk.

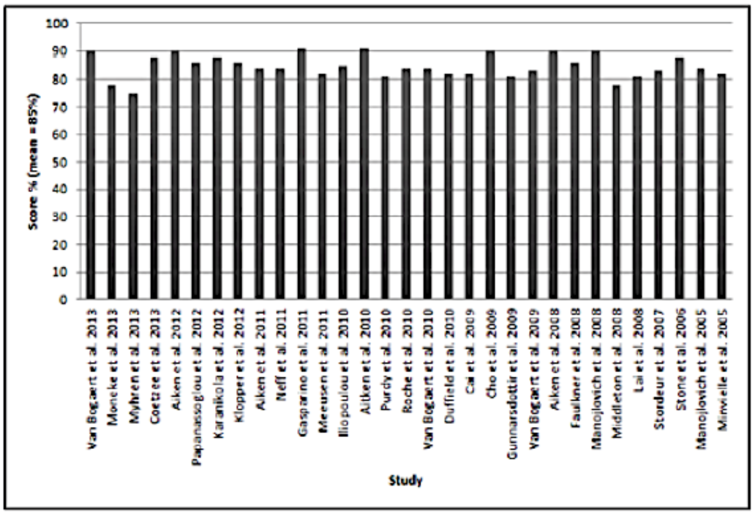


Figure 2. Relative derived quality index scores

Seven studies also employed randomization to control for confounding [3, 26, 44-47]. Overall the studies were primarily multi-site from a broad range of countries with two being multi-national [45, 48]. All studies were undertaken in an acute care environment with nine studies specific to adult ICU. A majority of studies were strong in terms of author expertise, clear study purpose, prospective study design and using psychometrically validated survey instruments. Results were comprehensively reported using clear descriptive summaries, empirical statistical analysis and identification of significant associations between structural characteristics of the workplace environment and nurse outcomes. These results were then further qualified through reporting of small standard errors, standard deviations and/or narrow confidence intervals. Overall the quality of the studies was high (see Figure 2) further supporting the inclusion of the twenty one identified nurse outcomes in the minimum dataset.

2.4 Data abstraction and synthesis

At the data analysis stage the authors followed the sequence proposed by Whittemore and Knafl (2005) including data reduction, data display, data comparison and verification of conclusions [25]. The data were reduced by extraction of nurse outcome measures as summarized in Table 1. This enabled a systematic identification of nurse outcomes associated with organizational factors from the described statistical testing, associations and conclusions. Nurse outcomes were reduced to a minimum dataset against which the survey instruments were aligned to assess the degree of congruence with the outcomes collected by each instrument.

Conclusion

Systematic appraisal found overall a high level of study quality in terms of research methodology and reporting. This provided the reviewers with confidence regarding the validity of nurse outcome measures identified. Further analysis of individual outcome measures was undertaken to statistically validate the final dataset of nurse outcome measures used to select an appropriate survey instrument.

3 Results

3.1 Nurse outcomes associated with organizational structures in the work environment

Repeated testing across multiple studies supports the reliability of nurse outcome measures. Figure 3 illustrates the frequency each nurse outcome was measured. Job satisfaction, intention to leave, leadership, emotional exhaustion (burnout), resourcing and staffing, and Nurse-Doctor collegiality were frequently used to study nurse work environments. In contrast, professional advancement and satisfaction with nursing in general were measured only once in separate large multicenter studies with high relative quality index scores [48, 49]. All twenty one nurse outcome measures were therefore retained for further evaluation in order of highest to lowest frequency.

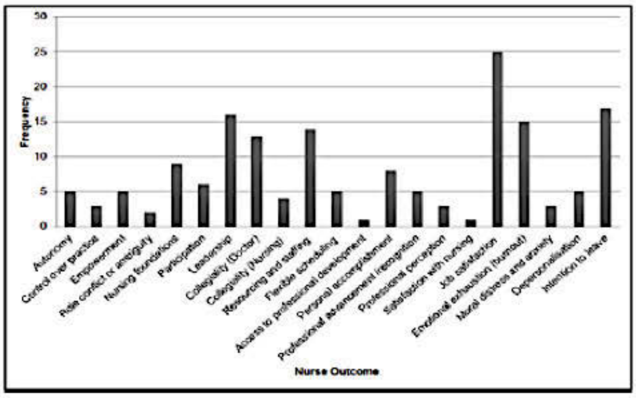


Figure 3. Repeatability of nurse outcome measures

3.1.1 Job satisfaction

Job satisfaction was strongly associated with the work environment in twenty five studies, including seven in ICU, with particular influence on intention to leave ($\overline{x}$ = -4.25; *SD* 1.61; $p < .01$) [50] and ($\beta = -0.28$; $p < .001$) [51]. A study of 935 ICU nurses identified a positive association between job satisfaction and nurse leadership ($r = 0.612$; $p < .001$), nurse-physician collegiality ($r = 0.454$; $p < .001$), staffing and resource adequacy ($r = 0.328$; $p < .001$), participation ($r = 0.307$; $p < .001$), foundations for quality care ($r = 0.437$; $p < .001$) and professional advancement ($r = 0.595$; $p < .001$) [52]. Job satisfaction was also found to have a significant correlation with increased autonomy ($r = 0.331$; $p < .001$) in a study of 431 ICU nurses [53].

3.1.2 Intention to leave

Seventeen studies, four in ICU, measured intention to leave. One large prospective study of 2323 ICU nurses found associations between intention to leave and professional status ($\overline{x}$ = 2.20, SE 0.08; $p < .001$), nursing leadership ($\overline{x}$ = 2.24, SE 0.08; $p < .001$), staffing and resource adequacy ($\overline{x}$ = 2.27, SE 0.06; $p < .001$), nursing foundations ($\overline{x}$ = 2.34, SE 0.06; $p < .001$), nurse–physician collegiality ($\overline{x}$ = 2.51, SE 0.06; $p < .001$) and rostering flexibility ($\overline{x}$ = 2.48, SE 0.09; $p < .001$) [3]. These associations were also found two ICU studies [48, 54] and five studies in acute care settings [42, 46, 51, 55, 56].

3.1.3 Leadership

Nursing leadership repeatedly demonstrated significant impact on job satisfaction, participation, retention and perceived professional status. Sixteen studies underscored the importance good nurse leadership with four studies conducted in ICU [3, 41, 57]. Stone *et al*. (2006) [3] identified that leadership in ICU was significantly associated with intention to leave ($\overline{x}$ = 2.28, SE 0.08; $p < .001$) while Klopper *et al*. (2012) [57] found a moderately strong correlation between leadership and a positively perceived ICU workplace ($r = 0.612$; $p < .01$). The bulk of the studies were conducted in non-ICU acute care environments. A large Australian multicenter study of 1,559 nurses identified a significant association between good clinical leadership and improved job satisfaction (OR 1.17; 95% CI 1.03-1.34; $p < .05$), and reduced intention to leave (OR 0.80; 95% CI 0.72-0.91; $p < .01$) [49].

3.1.4 Emotional exhaustion

Emotional exhaustion was explored in fifteen studies, three in ICU [50, 52, 54]. A significant association was consistently reported between the level of emotional exhaustion, or burn out, by nursing staff. The most frequently reported significant contributing factors to emotional exhaustion were staffing (OR 1.17, 95% CI 1.09-1.25; $p < .01$) [44] and (OR 050, 95% CI 0.34-0.73; $p < .005$) [54], sense of depersonalization ($r = -0.576$; $p < .01$) [52] and professional perception of nurses (OR 0.76, 95% CI 0.70-0.82; $p < .001$) [44]. A recent study concluded that emotional exhaustion is an important predictor of a broad range of nurse outcomes [56].

3.1.5 Resourcing and staffing

Fourteen studies found a significant association between perception of adequate resourcing and the work environment, with four studies conducted in ICU [3, 48, 52, 54]. A moderately strong correlation was also found with job satisfaction ($r = 0.328$; $p < .01$), while intention to leave (OR 1.23; 95% 0.88-1.72) was not statistically significant [57]. More broadly, in nine non-ICU studies, inadequate staffing and resourcing was associated with nurses having a negative perception of the work environment, including a large Australian study of 2,556 nurses ($t = -2.02$; $p = .04$) [60].

3.1.6 Nurse-doctor collegiality

Effective Nurse-Doctor collegiality repeatedly influenced perception of the workplace environment. Thirteen studies found a significant association between Nurse-Doctor collaboration and nurse autonomy, emotional exhaustion and anxiety, job satisfaction and satisfaction with nursing generally, with five of these studies conducted in ICU [3, 41, 46, 48, 52]. Of note is a study of 935 ICU nurses finding that Nurse-Doctor collegiality had a moderately strong correlation with job satisfaction ($r = 0.454$; $p < .01$) [52]. Staff also expressed a higher sense autonomy ($r = 0.319$; $p < .001$) [48]; job satisfaction (OR 3.94; 95% CI 2.90-7.07; $p < .0001$) [61] and ($r = 0.34$; $p < .001$) [62]; and nurse empowerment ($\beta = 0.27$; $p < .05$) [26] when Nurse–Doctor collegiality was high. Conversely, a number of studies found increased intention to leave associated with low collegiality ($r = 0.11$; $p < .05$) [42], (OR 2.26, 95% CI 1.23-4.14; $p < .05$) [61] and ($\overline{x} = 2.51$, SE 0.06, $p < .001$) [3].

3.1.7 Nursing foundations for quality care

High quality care, underpinned by a nursing foundation based on a defined nursing philosophy and nursing model of care, was found to be associated with a positive working environment in nine studies, three of which were conducted in ICU [3, 41, 52]. Typically this was manifested by increased job satisfaction both in ICU ($r = 0.437$; $p < .01$) [52] and in acute care areas (OR 1.26, 95% CI 1.09-1.45; $p < .01$) [63].

3.1.8 Personal accomplishment

A perception of higher personal accomplishment was associated with a positive work environment in eight studies, one of which undertaken in ICU [3]. Perceptions of high nurse autonomy ($r = 0.30$; $p < .01$) [42] and professional respect ($r = 0.32$; $p < .05$) [64], and increased job satisfaction ($r = 0.36$; $p < .001$) [65] were evident when the sense of personal accomplishment was high. This positive association was also found where there was effective Nurse-Doctor collegiality ($\beta = 3.20$, SE 0.8; $p < .01$), strong leadership ($\beta = 3.10$, SE 1.1; $p < .01$) and organizational support ($\beta = 2.70$, SE 1.0; $p < .01$) [61]. ICU nurses reported a higher intention to leave where they perceived a lack of personal accomplishment ($\overline{x} = 2.92$, SE 0.07; $p < .001$) [3].

3.1.9 Nurse participation

Increased participation in hospital affairs was associated with a positive work environment in six studies, with two conducted in ICU [41, 52]. Job satisfaction increased with higher participation ($r = 0.307$; $p < .01$) [52], (OR 1.16; 95% CI 1.03-1.31; $p < .05$) [63] and ($r = 0.36$; $p < .001$) [65]. Hospitals achieving magnet status typically have higher rates of participation ($t = 4.68$; $p < .01$) [60] and ($\overline{x} = 2.76$, *SD* 0.44; $p < .001$) [66].

3.1.10 Depersonalization

The perception of being depersonalized from the work environment was identified as a strong predictor of emotional exhaustion and job satisfaction in three acute care studies [42, 47, 56] and two in ICU [43, 52]. Perceived depersonalization had a moderate inverse association with reduced job satisfaction in a study of 129 ICU nurses (r = -0.313; $p < .001$) [43].

3.1.11 Professional recognition

Five studies consistently identified perceived professional recognition as a key nurse outcome, with one study conducted in ICU [52]. Professional recognition was found to increase nurses' job satisfaction in ICU (r = 0.595; $p < .01$) [52] and in acute care areas (OR 1.47; 95%CI 2.90-7.07; $p < .01$) [63] and (r = 0.25; $p < .001$) [65]. Professional recognition positively influences the perception of professional respect (r = 0.24; $p < .05$) [64].

3.1.12 Nurse autonomy

Perceived autonomy was found to be an important a nurse outcome measure in five studies, with two specific to ICU [48, 53]. In the largest prospective study of 431 ICU nurses increased job satisfaction had a moderate correlation with increased autonomy (r = 0.331; $p < .001$) [53] which was supported in a later study (r = 0.369; $p < .001$) [48]. ICU nurses also perceived higher autonomy when there was effective Nurse-Doctor collegiality (r = 0.319; $p < .001$), access to staff development (r = 0.369; $p < .001$) and perceived professional recognition (r = 0.211; p = .001) [48] and (r = 0.31; $p < .05$) [64]. Higher levels of emotional exhaustion (r = 0.37; $p < 0.01$) and perceived depersonalization (r = 0.18; $p < .05$) were associated with reduced autonomy as was low self-accomplishment (r = 0.30; $p < .01$) [42]. Intention to leave was also influenced by lower perceived autonomy (r = -0.142; p = .03) [48].

3.1.13 Nurse empowerment

A perception of increased empowerment was associated with a positive work environment in five studies conducted in acute care areas. Where nurses perceived increased empowerment job satisfaction was increased (r = 0.39; $p < .001$) [67], (r = 0.56; p = .01) [68], (β = 0.22; $p < .05$) [26] and (r = -0.11; $p < .01$) [65]. Empowerment increased with professional respect (r = 0.39; $p < .001$) [64] and effective Nurse-Doctor collegiality (β = 0.27; $p < .05$) [26], and was low when intention to leave was expressed (r = -0.31; p = .01) [68].

3.1.14 Flexible rostering

Five studies identified flexible rostering as a determinant of a positive work environment, two of which were conducted in ICU [3, 52]. Rostering inflexibility increases emotional exhaustion (r = -0.325; $p < .01$) [52] and intention to leave ($\bar{x}$ = 2.48, SE 0.09, $p < .001$) [3]. Organizational climate is rated higher ($\bar{x}$ = 4.2 *vs.* 3.8; $p < .001$) [69] and job satisfaction increases with flexible rostering (OR 1.16; 95%CI 1.02-1.30; $p < .05$) [63].

3.1.15 Nurse-nurse communication

Four studies investigated nurse-nurse communication in the workplace, with two conducted in ICU [41, 46]. Improved communication attributed to introducing formalized ICU nursing rounds improved perceptions of the workplace ($\bar{x}$ = 4.85 *vs.* post $\bar{x}$ = 5.36; p = .002) [41], while poor communication decreased job satisfaction (β = -0.097; p = .04) and compounded self-rated anxiety (r = -0.160; p = .001) [46]. The organizational climate benefited from improved nursing communication ($\bar{x}$ = 3.8 *vs.* $\bar{x}$ = 3.3; $p < .001$) [57] and interestingly the higher the number of ICU beds the lower the rating of effective nurse communication (r = -0.152; p = .002) [46]. This might be postulated to be associated with a large nursing workforce and depersonalization in larger ICUs. Further to this observation, though not statistically significant, was an increased intention to leave in larger capacity ICUs (OR 1.21; 95% CI 0.78-1.88; $p < .05$) [3].

3.1.16 Nurse outcome measures with limited supporting evidence

Three nurse outcome measures were identified that were supported by three studies or less. These outcomes, however, are consistent with recommended professional standards for healthy work environments and merit consideration [70]. Increased control over practice is associated with greater autonomy (r = 0.159; p = .005) [48] and where an inability to control practice exists this is associated with increased intention to leave ($r = -0.22$; $p < .05$) [42]. Moral distress was also found to increase where poor Nurse-Doctor collegiality existed ($r = -0.337$; $p < .001$) and with increased intention to leave ($r = 0.229$; $p = .01$) [48].

3.1.17 Conclusion

Twenty one nurse outcomes in acute and intensive care work environment were identified and evaluated using the following steps: (1) assessing the quality of the relevant primary study and generating a quality index score; (2) assessing the risk of bias for each primary study; (3) examining the significance of the association between nurse outcome measures and structural features of the workplace environment; and (4) evaluating the repeatability and consistency of nurse outcome measures. Following this process all twenty one nurse outcome measures were retained to inform selection of a nurse survey instrument for ICU.

4 Discussion and instrument selection

Internationally, professional nursing associations recommend standards for healthy work environments that promote the balance of an organization's objectives with favorable nurse outcomes [71, 72]. Where this balance is achieved magnet health care organizations evolve characterized by high quality nursing care, increased job satisfaction and improved nurse outcomes [66, 73, 74].

Magnet organizations value nursing practice, workplace culture and climate, as well as material factors such as rates of pay [74-76]. Strong leadership is a key factor and is considered to influence job satisfaction, participation levels, staff retention and perceived professional status [77-79].

Healthy work environments recognize strong nursing foundations, active staff participation, empowerment and team building as a basis for high quality care [80, 81]. An effective ICU clinical team is further underpinned by a high level of Nurse-Doctor collegiality to sustain a positive organizational culture and climate [82-84].

Dissatisfaction and worsening staff outcomes are associated with health service restructuring aimed at improving productivity through work intensification [85-87]. Staff outcomes are also influenced by rostering, poor physician-nurse interactions, new technology, staff shortages, unpredictable work flow, lack of control over practice and a perception that patient care is not coordinated, evidence-based or unsafe [39, 48, 49].

Job satisfaction is associated consistently with positive work environment characteristics including nurse autonomy, staffing and resourcing, opportunities for professional advancement and positive acknowledgement [32]. Intention to leave is reduced and job satisfaction is high where staff perceive they have equitable rosters, flexibility and control over personal time [16, 88].

Structural and psycho-sociological factors determine nurse outcomes making it essential that both are appropriately captured in organizational survey instruments. High interdependence exists between organizational, interpersonal and individual behavior determinants of a health work environment [86].

Perceptions held by nurses on how structural factors impact on them personally and may be manifested as emotional exhaustion [16]. Emotional exhaustion refers to the depletion of aroused emotional states, such as a nurse feeling too emotionally drained to adequately care for patients. Combined with a sense of low personal accomplishment and depersonalization then these perceptions are manifested as 'burn-out' and increased intention to leave [89].

Lack of personal accomplishment is linked to an individual's lower perception of self-competence and empowerment [90]. Empowerment is an important component of transformational leadership and the trust underpinning staff autonomy and job satisfaction [91]. Effective communication supports control over practice, decision-making at the bedside and teamwork, all determinants of a positive workplace and ultimately a positive work environment [48, 92].

Nurse outcomes reflect external structural factors and individual perceptions both of which are influenced by the work environment as recognized in professional standards and magnet hospitals [70, 74, 93]. The most appropriate survey instrument should capture the impact of structural factors and individual perceptions and thereby align closely with the nurse outcome dataset identified.

Repeated testing of instruments over time in similar nurse populations provides an indication of their reproducibility and reliability. Taking into account the level of instrument congruence with the nurse outcome dataset, evidence of content and contextual validity and the frequency of testing across acute care settings including ICU (see Figure 4) enabled the selection of three survey instruments for further psychometric assessment.

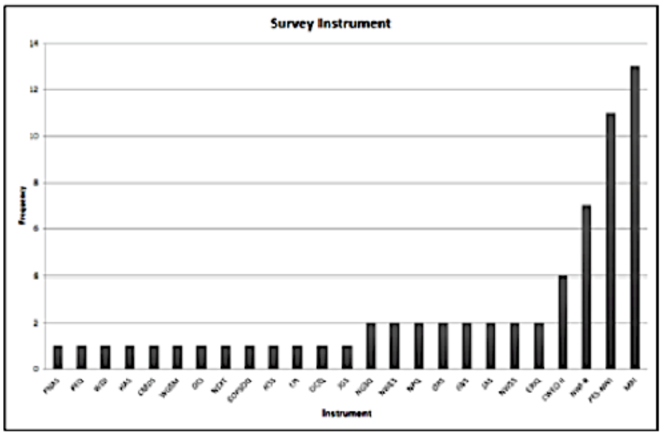


Figure 4. Survey instrument frequency of use

The Nurse Work Index-Revised (NWI-R) [94], Practice Environment Scale-Nurse Work Index (PES-NWI) [95] and Maslach's Burnout Inventory (MBI) [96] demonstrated highest congruence and repeated testing warranting further psychometric validation.

Critical appraisal of the psychometric properties and predictive validity, of nurse survey instruments, is well established [97-99]. Each survey instrument selected has undergone this process in a broad range of acute healthcare environments internationally including Australia [100], Brazil [42], China [101], Japan [102], Spain [103], the United Kingdom [31], United States [104] and multi-nationally [105]. A summary of the psychometric assessment for the NWI-R, PES-NWI and MBI is provided in Table 2.

All three survey instruments were tested repeatedly in multicenter studies involving large samples of nurses. Similarly, all instruments had been tested in acute care and ICU environments with PES-NWI being used more frequently in ICU. The content validity of the NWI-R and PES-NWI has direct relevance to the climate and culture of nurses' work environment.

The MBI focused on interpersonal and psychosocial aspects, with some relevance to organizational, factors but with a greater emphasis on individual perceptions and emotions. All three instruments have an acceptable level of reliability, with the Cronbach alpha mean composite coefficient for all studies being above 0.7, which is recommended as the minimum threshold to establish reliability [106].

Congruence with the nurse outcome measures was high for both the NWI-R (aligned with sixteen outcomes) and the PES-NWI (aligned with seventeen outcomes). The MBI fulfills six of the nurse outcome measures: level of participation, job satisfaction, emotional exhaustion (burnout), moral distress and anxiety, and depersonalization. Four outcomes captured by the MBI are not captured by the NWI-R and PES-NWI providing the justification to add subscales from the MBI to the nurse survey instrument selected.

Table 2. Survey instrument validity and congruence with nurse outcomes

Quality and Validity Factors	Survey Instrument		
	NWI-R	PES-NWI	MBI
Frequency	7	11	13
Testing repeated	Yes (multicentre)	Yes (multicentre)	Yes (multicentre)
Large study population	Range 155 to 2,287	Range 67 to 98,116	Range 155 to 98,116
Tested in nursing populations	Yes	Yes	Yes
Conducted in ICU	2/7	4/11	3/13
Organizational content validity	Yes	Yes	Yes (interpersonal focus)
Cronbach alpha: mean composite coefficient	α 85	α 81	α 82
Congruence with Nurse Outcomes			
Nurse Outcome	**Measured**		
Autonomy	Yes	Yes	No
Control over practice	Yes	Yes	No
Empowerment	Yes	Yes	No
Role conflict or ambiguity	Yes	Yes	No
Nursing foundations	Yes	Yes	No
Participation	Yes	Yes	Optional questions
Leadership	Yes	Yes	No
Collegiality (Doctor)	Yes	Yes	No
Collegiality (Nursing)	Yes	Yes	No
Resourcing and staffing	Yes	Yes	No
Flexible scheduling	Yes	Yes	No
Access to professional development	Yes	Yes	No
Personal accomplishment	Yes	Yes	Yes
Professional advancement /recognition	Yes	Yes	No
Professional perception	Yes	Yes	No
Satisfaction with nursing	No	Yes	No
Job satisfaction	No	No	Yes
Emotional exhaustion (burnout)	No	No	Yes
Moral distress and anxiety	No	No	Yes
Depersonalisation	No	No	Yes
Intention to leave	Yes	Yes	Yes

Higher congruence with the identified nurse outcomes, demonstrated content and construct validity, an ability to discriminate positive work environment characteristics, repeated testing and strong psychometric properties supports selection of the PES-NWI as the preferred survey instrument.

The PES-NWI seeks to elicit information from staff regarding their felt experience and perceptions [100, 107, 108]. Factor analysis of data from magnet hospitals involving statistical testing of observed variables to determine correlation, internal consistency, reliability and validity across organizational domains, including ICU, was used to develop the PES-NWI [108]. A large number of studies and industry reports published since 2002 describe the use, modification, and scoring variations of the PES-NWI in five different countries, translated to three languages, across ten practice settings [101, 103]. In a recent

Australian study by Parker *et al*. (2010) [100], the construct validity and reliability of the PES-NWI was tested in a random sample of 3,000 nurses working in private and public sectors demonstrating strong internal consistency with a Cronbach alpha of 0.948. The study concluded that the PES-NWI is a reliable survey instrument for a range of clinical settings with ongoing refinement and testing based on large nursing populations underpinning its construct validity and reliability for the assessment of nurses work environment in acute care and ICU settings.

4.1 Limitations

This review provides an overview of nurse outcomes found to reflect structural factors within an organization and uses this outcome profile to select an appropriate survey instrument. Although a variety of study designs were included in the literature search, the studies included in the analysis were primarily cross sectional and therefore the ability to confer causality is significantly limited. Studies undertaken across a broad range of countries were included, however, only those studies published in English were reviewed which may limit generalization of any findings. Terminology for similar nurse outcomes varied widely requiring interpretation for classification purposes. Lastly, this literature review had a broad international perspective but does not account for variability in different health systems. These limitations may lead restrict the generalization of the findings of this review without further contextual validation.

4.2 Implications for nursing management

This integrative review identifies the key constructs of a survey instrument that will assist policy makers and managers to better understand the factors contributing to a sustainable intensive care nurse workforce in the face of organizational change.

5 Conclusion

This literature review progressed through several stages of analysis to identify the most effective survey instrument to evaluate the working environment of nurses in ICU. The impact of structural factors on the work environment can be assessed by the nurse outcome measures captured within the PES-NWI survey instrument. The addition of the MBI is recommended to capture individual emotional responses. An instrument that incorporates both the PES-NWI and MBI subscales is most appropriate to evaluate the environment of nurses working in ICUs world-wide.

Acknowledgements

The authors would like to express their gratitude to Dr Eileen Lake for giving permission to reproduce the PES-NWI. The authors also would like to express their gratitude to Mind Garden, Inc. for permission so reproduce an extract of the MBI Human Services Survey.

References

[1] Adhikari, N., Rubenfeld, G. Worldwide demand for critical care. Current Opinion in Critical Care. 2011; 17(6): 620-5. PMid: 22067878. http://dx.doi.org/10.1097/MCC.0b013e32834cd39c

[2] Vincent, J. Critical care – where have we been and where are we going? Critical Care. 2013; 17(Suppl 1): S2. PMid: 23514264.

[3] Stone, P., Larson, E., Mooney-Kane, C., Smolowitz, J., Lin, S., Dick, A. Organizational climate and intensive care unit nurses' intention to leave. Critical Care Medicine. 2006; 34(7): 1907-12. PMid: 16625126. http://dx.doi.org/10.1097/01.CCM.0000218411.53557.29

[4] Kahn, J., Linde-Zwirble, W., Wunsch, H., Barnato, A., Iwashyna, T., Roberts, M., *et al*. Potential Value of Regionalized Intensive Care for Mechanically Ventilated Medical Patients. Am. J. Respir. Crit. Care Med. 2008; 177(3): 285-91. PMid: 18006884. http://dx.doi.org/10.1164/rccm.200708-1214OC

[5] Nguyen, Y., Kahn, J., Angus, D. Reorganizing Adult Critical Care Delivery: The Role of Regionalization, Telemedicine, and Community Outreach. Am. J. Respir. Crit. Care Med. 2010; 181(11): 1164-9. PMid: 20224067. http://dx.doi.org/10.1164/rccm.200909-1441CP

[6] Meadows, C., Rattenberry, W., Waldmann, C. Centralisation of specialist critical care services. Journal of the Intensive Care Society. 2011; 12(2): 87-9.

[7] Rashid, M. Technology and the future of intensive care unit design. Critical Care Nursing Quarterly. 2011; 34(4): 332-60. PMid: 21921718. http://dx.doi.org/10.1097/CNQ.0b013e31822ba782

[8] College of Intensive Care Medicine of Australia and New Zealand 2010, Minimum standards for transport of critically ill patients, Melbourne IC-10.

[9] Valentin, A., Ferdinande, P. Recommendations on basic requirements for intensive care units: structural and organizational aspects. Intensive Care Medicine. 2011; 37(10): 1575. PMid: 21918847. http://dx.doi.org/10.1007/s00134-011-2300-7

[10] Roberts, D., Clark, H., Rock, B. Development and implementation of a regional intensive care health service model. Leadership in Health Services. 2013; 26(3): 232-6. http://dx.doi.org/10.1108/LHS-02-2013-0012

[11] Braungardt, T., Fought, S. Leading Change During an Inpatient Critical Care Unit Expansion. Journal of Nursing Administration. 2008; 38(11): 461-7. PMid: 18997550. http://dx.doi.org/10.1097/01.NNA.0000339476.73090.33

[12] Falahinia, G., Zareian, A., Oshvandi, K., Farhanchi, A., Moghimbigi, A. Comparison of intensive care units Structural Standards. Iranian Journal of Critical Care Nursing. 2013; 5(4): 222-7.

[13] Terwiesch, C., Diwas, K., Kahn, J. Working with capacity limitations: operations management in critical care. Critical Care vol. 2011; 15(4): 308. PMid: 21892976. http://dx.doi.org/10.1186/cc10217

[14] Rhodes, A., Moreno, R., Chiche, J. ICU structures and organization: putting together all the pieces of a very complex puzzle. Intensive Care Medicine. 2011; 37(10): 1569. PMid: 21918846. http://dx.doi.org/10.1007/s00134-011-2332-z

[15] Welton, J., Meyer, A., Mandelkehr, L., Fakhry, S., Jarr, S. Outcomes of and Resource Consumption by High-Cost Patients in the Intensive Care Unit. American Journal of Critical Care. 2002; 11: 467-73. PMid: 12233972.

[16] Moneke, N., Umeh, O. Factors Influencing Critical Care Nurses Perception of Their Overall Job Satisfaction: An Empirical Study. The Journal of Nursing Administration. 2013; 43(4): 201-7. PMid: 23528685. http://dx.doi.org/10.1097/NNA.0b013e31828958af

[17] Zayan, N., Reizian, A., Hamouda, G. Relationship between Organizational Climate and Nurse Outcomes. Journal of American Science. 2013; 2(9): 184-92.

[18] Hinno, S., Partanen, P., Vehviläinen, J. The professional nursing practice environment and nurse-reported job outcomes in two European countries: a survey of nurses in Finland and the Netherlands. Scandinavian Journal of Caring Sciences. 2012; 26(1): 133-43. PMid: 22032723. http://dx.doi.org/10.1111/j.1471-6712.2011.00920.x

[19] Twigg, D., McCullough, K. Nurse retention: A review of strategies to create and enhance positive practice environments in clinical settings. International Journal of Nursing Studies. 2014; 51(1): 85-92. PMid: 23809644. http://dx.doi.org/10.1016/j.ijnurstu.2013.05.015

[20] Garland, A. Figuring out what works: a need for more and better studies on the relationship between ICU organization and outcomes. Critical Care (London, England). 2010; 14(1): 108. PMid: 20156315. http://dx.doi.org/10.1186/cc8843

[21] Luzinski, C., Lundmark, V. State of the Science Related to Nurse Work Environments, Safe Practices, and Organizational Outcomes. Journal of Nursing Administration. 2012; 42(10): S1-S2. PMid: 22976888. http://dx.doi.org/10.1097/01.NNA.0000420388.10661.75

[22] Schloffman, D., Hage, A. Listen to your nurses! Improving work environments. Nursing Management. 2012; 43(9): 50-3. PMid: 22929076. http://dx.doi.org/10.1097/01.NUMA.0000418778.76679.3d

[23] Cooper, H. Scientific Guidelines for Conducting Integrative Research Reviews. Review of Educational Research. 1982; 52(2): 291-302. http://dx.doi.org/10.3102/00346543052002291

[24] Dixon-Woods, M., Agarwal, S., Young, B., Jones, D., Sutton, A. Integrative approaches to qualitative and quantitative evidence. Health Development Agency. London. 2004.

[25] Whittemore, R., Knafl, K. The integrative review: updated methodology. J Adv Nurs. 2005; 52(5): 546-53. PMid: 16268861. http://dx.doi.org/10.1111/j.1365-2648.2005.03621.x

[26] Manojlovich, M. Linking the practice environment to nurses' job satisfaction through nurse-physician communication. Journal of Nursing Scholarship. 2005; 37(4):367-73. PMid: 16396411. http://dx.doi.org/10.1111/j.1547-5069.2005.00063.x

[27] Haut, E., Sicoutris, C., Meredith, D., Sonnad, S., Reilly, P., Schwab, C., *et al.* Improved nurse job satisfaction and job retention with the transition from a "mandatory consultation" model to a "semiclosed" surgical intensive care unit: A 1-year prospective evaluation. Critical Care Medicine. 2006; 34(2): 387-95. PMid: 16424719. http://dx.doi.org/10.1097/01.CCM.0000198104.28666.C0

[28] Spetz, J., Herrera, C. Changes in nurse satisfaction in California, 2004 to 2008. Journal of Nursing Management. 2010; 18(5): 564-72. PMid: 20636505. http://dx.doi.org/10.1111/j.1365-2834.2010.01117.x

[29] Manojlovich, M., Antonakos, C., Ronis, D. Intensive Care Units, Communication Between Nurses and Physicians, and Patients' Outcomes. American Journal of Critical Care. 2009; 18(1): 21-30. PMid: 19116401. http://dx.doi.org/10.4037/ajcc2009353

[30] Cho, S., Mark, B., Yun, S., June, K. Differences in intensive care unit work environments among and within hospitals using subscales and a composite measure of the Revised Nursing Work Index. Journal of Advanced Nursing. 2011. PMid: 21645043. http://dx.doi.org/10.1111/j.1365-2648.2011.05713.x

[31] Duddle, M., Boughton, M. Development and psychometric testing of the Nursing Workplace Relational Environment Scale (NWRES). J Clin Nurs. 2009; 18(6): 902-9. PMid: 19239669.

[32] Li, Y., Lake, E., Sales, A., Sharp, N., Greiner, G., Lowy, E., *et al.* Measuring nurses' practice environments with the revised nursing work index: Evidence from registered nurses in the veterans' health administration. Research in Nursing & Health. 2007; 30(1): 31-44. PMid: 17243106. http://dx.doi.org/10.1002/nur.20172

[33] Liou, S., Cheng, C. Using the Practice Environment Scale of the Nursing Work Index on Asian nurses. Nursing Research. 2009; 58(3): 218-25. PMid: 19448526. http://dx.doi.org/10.1097/NNR.0b013e3181a308cd

[34] Slater, P., O'Halloran, P., Connolly, D., McCormack, B. Testing of the Factor Structure of the Nursing Work Index-Revised. Worldviews on Evidence-Based Nursing. 2010; 7(3): 123-34. PMid: 19656353. http://dx.doi.org/10.1111/j.1741-6787.2009.00158.x

[35] Miller, J. Critical Review of Quantitative Research. British Columbia. Viewed March 2013. Available from: http://www.northernhealth.ca/YourHealth/ResearchandEvaluation/ResearchEvaluationEIPResources.aspx.

[36] Von Elm, E., Altman, D., Egger, M., Pocock, S., Gøtzsche, P., Vandenbroucke, J. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for reporting observational studies. Preventive Medicine. 2007; 45(4): 247-51. PMid: 17950122. http://dx.doi.org/10.1016/j.ypmed.2007.08.012

[37] Evans, D. Hierarchy of evidence: a framework for ranking evidence evaluating healthcare interventions. Journal of Clinical Nursing. 2003; 12(1):77-84. PMid: 12519253. http://dx.doi.org/10.1046/j.1365-2702.2003.00662.x

[38] Beck, C. The effects of postpartum depression on maternal-infant interaction: A meta-analysis. Nursing Research. 1995; 44(5): 298-304. PMid: 7567486. http://dx.doi.org/10.1097/00006199-199509000-00007

[39] Li, Y., Jones, C. A literature review of nursing turnover costs. Journal of Nursing Management. 2012; 21(3): 405-18. PMid: 23406301. http://dx.doi.org/10.1111/j.1365-2834.2012.01411.x

[40] Inglis, S., Clark, R., McAlister, F., Ball, J., Lewinter, C., Cullington, D., *et al.* Structured telephone support or telemonitoring programmes for patients with chronic heart failure. Cochrane database of systematic reviews. 2010; no. 8: 1-142.

[41] Aitken, L., Burmeister, E., Clayton, S., Dalais, C., Gardner, G. The impact of Nursing Rounds on the practice environment and nurse satisfaction in intensive care: Pre-test post-test comparative study. International Journal of Nursing Studies. 2010; 15.

[42] Gasparino, R., De Brito Guirardello, E., Aiken, L. Validation of the Brazilian version of the Nursing Work Index-Revised (B-NWI-R). Journal of Clinical Nursing. 2011; 3494-3501. PMid: 21749511. http://dx.doi.org/10.1111/j.1365-2702.2011.03776.x

[43] Myhren, H., Ekeberg, O., Stokland, O. Job Satisfaction and Burnout among Intensive Care Unit Nurses and Physicians. Critical Care Research and Practice. 2013; 1-6. http://dx.doi.org/10.1155/2013/786176

[44] Aiken, L., Clarke, S., Sloane, E., Lake, E., Cheney, T. Effects of Hospital Care Environment on Patient Mortality and Nurse Outcomes. Journal of Nurse Administration. 2008; 38(5): 223-9. PMid: 18469615. http://dx.doi.org/10.1097/01.NNA.0000312773.42352.d7

[45] Aiken, L., Sloane, D., Clarke, S., Poghosyan, L., Cho, E., You, L., *et al.* Importance of work environments on hospital outcomes in nine countries. International Journal for Quality in Health Care. 2011; 23(4): 357-64. PMid: 21561979. http://dx.doi.org/10.1093/intqhc/mzr022

[46] Karanikola, M., Papathanassoglou, E., Kalafati, M., Stathopoulou, H., Mpouzika, M., Goutsikas, C. Exploration of the Association between Professional Interactions and Emotional Distress of Intensive Care Unit Nursing Personnel. Dimensions of Critical Care Nursing. 2012; 31(1) 37-45. PMid: 22156812. http://dx.doi.org/10.1097/DCC.0b013e31823a55b8

[47] Van Bogaert, P., Clarke, S., Roelant, E., Meulemans, H., Van de Heyning, P. Impacts of unit-level nurse practice environment and burnout on nurse-reported outcomes: a multilevel modelling approach. Journal of Clinical Nursing. 2010; 19(11-12): 1664-74. PMid: 20579204. http://dx.doi.org/10.1111/j.1365-2702.2009.03128.x

[48] Papathanassoglou, E., Karanikola, M., Kalafati, M., Giannakopoulou, M., Lemonidou, C., Albarran, J. Professional autonomy, collaboration with physicians, and moral distress among European intensive care nurses. American Journal of Critical Care. 2012; 21(2): 41-52. PMid: 22381995. http://dx.doi.org/10.4037/ajcc2012205

[49] Duffield, C., Diers, D., O'Brien-Pallas, L., Aisbett, C., Roche, M., King, M., *et al.* Nursing staffing, nursing workload, the work environment and patient outcomes. Applied Nursing Research. 2011; 24(4): 244-55. PMid: 20974086. http://dx.doi.org/10.1016/j.apnr.2009.12.004

[50] Lai, H., Lin, Y., Chang, H., Wang, S., Liu, Y., Lee, H., *et al.* Intensive care unit staff nurses: predicting factors for career decisions. Journal of Clinical Nursing. 2008; 17(14): 1886-96. PMid: 18592616. http://dx.doi.org/10.1111/j.1365-2702.2007.02180.x

[51] Meeusen, V., Van Dam, K., Brown-Mahoney, C., Van Zundert, A., Knape, H. Understanding nurse anesthetists' intention to leave their job: how burnout and job satisfaction mediate the impact of personality and workplace characteristics. Health Care Manage Review. 2011; 36(2): 155-63. PMid: 21317664. http://dx.doi.org/10.1097/HMR.0b013e3181fb0f41

[52] Klopper, H., Coetzee, S., Pretorius, R., Bester, P. Practice environment, job satisfaction and burnout of critical care nurses in South Africa. Journal of Nursing Management. 2012; 20(5): 685-95. PMid: 22823225. http://dx.doi.org/10.1111/j.1365-2834.2011.01350.x

[53] Iliopoulou, K., While, A. Professional autonomy and job satisfaction: survey of critical care nurses in mainland Greece. Journal of Advanced Nursing. 2010; 66(11): 2520-31. PMid: 20735503. http://dx.doi.org/10.1111/j.1365-2648.2010.05424.x

[54] Cho, S., June, K., Kim, Y., Cho, Y., Yoo, C., Yun, S., *et al.* Nurse staffing, quality of nursing care and nurse job outcomes in intensive care units. Journal of Clinical Nursing. 2009; 18(12): 1729-37. PMid: 19646118. http://dx.doi.org/10.1111/j.1365-2702.2008.02721.x

[55] Coetzee, S., Klopper, H., Ellis, S., Aiken, L. A tale of two systems—Nurses practice environment, wellbeing, perceived quality of care and patient safety in private and public hospitals in South Africa: A questionnaire survey. International Journal of Nursing Studies. 2013; 50(2): 162-73. PMid: 23218020. http://dx.doi.org/10.1016/j.ijnurstu.2012.11.002

[56] Van Bogaert, P., Olaf, T., Weeks, S., Van Heusden, D., Wouters, K., Franck, E. Nursing Unit Teams Matter: Impact of Unit-level Nurse Practice Environment, Nurse Work Characteristics, and Burnout on Nurse Reported Job Outcomes, and Quality of Care, and Patient Adverse Events. International Journal of Nursing Studies. 2013.

[57] Klopper, H., Aiken, L., Coetzee, S. Hospital Work Environments, Nurse Burnout and Job Dissatisfaction: A View in the Mirror of International Evidence. Paper presented to the Sigma Theta Tau International Biennial Convention (41st). Texas USA. 2012. http://hdl.handle.net/10755/201847.

[58] Aiken, L., Patrician, P. Measuring Organizational Traits of Hospitals: The Revised Nursing Work Index. Nursing Research. 2000; 49(3): 146-53. PMid: 10882319. http://dx.doi.org/10.1097/00006199-200005000-00006

[59] Neff, D., Cimiotti, J., Heusinger, A., Aiken, L. Nurse Reports from the Frontlines: Analysis of a Statewide Nurse Survey. Nursing Forum. 2011; 46(1): 4-10. PMid: 21306390. http://dx.doi.org/10.1111/j.1744-6198.2010.00201.x

[60] Roche, M., Duffield, C. A Comparison of the Nursing Practice Environment in Mental Health and Medical-Surgical Settings. Journal of Nursing Scholarship. 2010; 42(2): 195-206. PMid: 20618603. http://dx.doi.org/10.1111/j.1547-5069.2010.01348.x

[61] Van Bogaert, P., Clarke, S., Vermeyen, K., Meulemans, H., Van de Heyning, P. Practice environments and their associations with nurse-reported outcomes in Belgian hospitals: Development and preliminary validation of a Dutch adaptation of the Revised Nursing Work Index. International Journal of Nursing Studies. 2009; 46(1): 55-65. PMid: 18789437. http://dx.doi.org/10.1016/j.ijnurstu.2008.07.009

[62] Manojlovich, M., Laschinger, H. Application of the Nursing Worklife Model to the ICU Setting. Critical Care Nursing Clinics of North America. 2008; 20(4): 481-7. PMid: 19007714. http://dx.doi.org/10.1016/j.ccell.2008.08.004

[63] Duffield, C., Roche, M., Blay, N., Stasa, H. Nursing unit managers, staff retention and the work environment. Journal of Clinical Nursing. 2010; 20(1-2): 23-33. PMid: 21158986. http://dx.doi.org/10.1111/j.1365-2702.2010.03478.x

[64] Faulkner, J., Laschinger, H. The effects of structural and psychological empowerment on perceived respect in acute care nurses. J Nurs Manag. 2008; 16(2): 214-21. PMid: 18269553. http://dx.doi.org/10.1111/j.1365-2834.2007.00781.x

[65] Minvielle, M., Aegerter, P., Dervaux, B., Boumendil, A., Retbif, A., Jars-Guincestre, M., *et al.* Culture, organization, and management in intensive care: construction and validation of a multidimensional questionnaire. Journal of Critical Care. 2005; 20(2): 126-38. PMid: 16139153. http://dx.doi.org/10.1016/j.jcrc.2004.12.003

[66] Middleton, S., Griffiths, R., Fernandez, R., Smith, B. Nursing practice environment: How does one Australian hospital compare with magnet hospitals? International Journal of Nursing Practice. 2008; 14(5): 366-72. PMid: 18808537. http://dx.doi.org/10.1111/j.1440-172X.2008.00708.x

[67] Purdy, N., Spence Laschinger, H., Finegan, J., Kerr, M., Olivera, F. Effects of work environments on nurse and patient outcomes. Journal of Nursing Management. 2010; 18(8): 901-13. PMid: 21073564. http://dx.doi.org/10.1111/j.1365-2834.2010.01172.x

[68] Cai, C., Zhou, Z. Structural empowerment, job satisfaction, and turnover intention of Chinese clinical nurses. Nurs Health Sci. 2009; 11(4): 397-403. PMid: 19909448. http://dx.doi.org/10.1111/j.1442-2018.2009.00470.x

[69] Stordeur, S., D'Hoore, W. Organizational configuration of hospitals succeeding in attracting and retaining nurses. Journal of Advanced Nursing. 2007; 57(1): 45-58. PMid: 17184373. http://dx.doi.org/10.1111/j.1365-2648.2006.04095.x

[70] American Association of Critical-Care Nurses. AACN standards for establishing and sustaining healthy work environments: a journey to excellence. American Journal of Critical Care. 2005; 14(3): 187-97. PMid: 15840893.

[71] International Council of Nurses. Management of nursing and health care services: position statement, Wiley, Geneva, Switzerland. 2010.

[72] Ritter, D. The relationship between healthy work environments and retention of nurses in a hospital setting. Journal of Nursing Management. 2011; 19(1): 27-32. PMid: 21223402. http://dx.doi.org/10.1111/j.1365-2834.2010.01183.x
[73] Callicutt, D., Norman, K., Smith, L., Nichols, A., Kring, D. Building an Engaged and Certified Nursing Workforce. Nursing Clinics of North America. 2011; 46(1): 81-7. PMid: 21320663. http://dx.doi.org/10.1016/j.cnur.2010.10.004
[74] Hickey, P., Gauvreau, K., Connor, J., Sporing, E., Jenkins, K. The Relationship of Nurse Staffing, Skill Mix, and Magnet Recognition to Institutional Volume and Mortality for Congenital Heart Surgery. The Journal of Nursing Administration. 2010; 40(5): 226-32. PMid: 20431457. http://dx.doi.org/10.1097/NNA.0b013e3181da3f71
[75] Soh, K., Soh, K., Davidson, P. The role of culture in quality improvement in the intensive care unit: A literature review. Journal of Hospital Administration. 2013; 2(2): 97-104. http://dx.doi.org/10.5430/jha.v2n2p97
[76] Upenieks, V. The Interrelationship of Organizational Characteristics of Magnet Hospitals, Nursing Leadership, and Nursing Job Satisfaction. Health Care Manager. April/May/June, 2003; 22(2): 83-98.
[77] Abualrub, R., Alghamdi, M. The impact of leadership styles on nurses' satisfaction and intention to stay among Saudi nurses. Journal of Nursing Management. 2012; 20(5): 668-78. PMid: 22823223. http://dx.doi.org/10.1111/j.1365-2834.2011.01320.x
[78] O'Brien-Pallas, L., Catling-Paull, C., Duffield, C., Roche, M. The Implications of Staff 'Churn' for Nurse Managers, Staff, And Patients. Nursing Economics. 2009; 27(2): 103-10. PMid: 19492774.
[79] Shirey, M. Authentic Leadership, Organizational Culture, and Healthy Work Environments. Critical Care Nursing Quarterly. 2009; 32(3): 189-98. PMid: 19542970. http://dx.doi.org/10.1097/CNQ.0b013e3181ab91db
[80] Lake, E. The Nursing Practice Environment. Medical Care Research and Review. 2007; 64(2): 104S-22S. PMid: 17406014. http://dx.doi.org/10.1177/1077558707299253
[81] Stockwell, D., Slonim, A. Quality and safety in the intensive care unit. Journal of Intensive Care Medicine (Sage Publications Inc.). 2006; 21(4): 199-210.
[82] Lin, F., Chaboyer, W., Wallis, M. A literature review of organizational, individual and teamwork factors contributing to the ICU discharge process. Australian critical care: official journal of the Confederation of Australian Critical Care Nurses. 2009; 22(1): 29-43. PMid: 19138531. http://dx.doi.org/10.1016/j.aucc.2008.11.001
[83] Pacheco, E., Campos, I., Seixas, J., Conejo, S., Vieira, H., Mazutti, S., *et al*. Daily multidisciplinary rounds reduce ICU length of stay. Critical Care. 2011; 15(0): 1-31.
[84] Parker, V., Giles, M., Higgins, I. Challenges confronting clinicians in acute care. J Nurs Manag. 2009; 17(6): 667-78. PMid: 19694911. http://dx.doi.org/10.1111/j.1365-2834.2009.01009.x
[85] Gershon, R., Stone, P., Bakken, S., Larson, E. Measurement of Organizational Culture and Climate in Healthcare. Journal of Nursing Administration. 2004; 34(1): 33-40. PMid: 14737033. http://dx.doi.org/10.1097/00005110-200401000-00008
[86] Hayes, B., Bonner, A., Pryor, J. Factors contributing to nurse job satisfaction in the acute hospital setting: a review of recent literature. Journal of Nursing Management. 2010; 18(7): 804-14. PMid: 20946216. http://dx.doi.org/10.1111/j.1365-2834.2010.01131.x
[87] O'Brien-Pallas, L., Murphy, G., Shamian, J., Li X, Hayes, L. Impact and determinants of nurse turnover: a pan-Canadian study. Journal of Nurse Management. 2010; 18(8): 1073-86. PMid: 21073578. http://dx.doi.org/10.1111/j.1365-2834.2010.01167.x
[88] Webster, J., Flint, A., Courtney, M. A new practice environment measure based on the reality and experiences of nurses working lives. Journal of Nursing Management. 2009; 17(1): 38-48. PMid: 19166521. http://dx.doi.org/10.1111/j.1365-2834.2008.00908.x
[89] Bartram, T., Casimir, G., Djurkovic, N., Leggat, S., Stanton, P. Do perceived high performance work systems influence the relationship between emotional labour, burnout and intention to leave? A study of Australian nurses. Journal of Advanced Nursing. 2012; 68(7): 1567-78. PMid: 22384981. http://dx.doi.org/10.1111/j.1365-2648.2012.05968.x
[90] Lederer, W., Kinzl, J.F., Traweger, C., Dosch, J., Sumann, G. Fully developed burnout and burnout risk in intensive care personnel at a university hospital. Anaesthesia and Intensive Care. 2008; 36(2): 208-13. PMid: 18361012.
[91] Mullarkey, M., Duffy, A., Timmins, F. Trust between nursing management and staff in critical care: a literature review. Nursing in Critical Care. 2011; 16(2): 85-91. PMid: 21299761. http://dx.doi.org/10.1111/j.1478-5153.2010.00404.x
[92] Groff-Paris, L., Terhaar, M. Using Maslow's pyramid and the national database of nursing quality indicators(R) to attain a healthier work environment. Online Journal of Issues in Nursing. 2011; 16(1): 1-13.
[93] Spence Laschinger, H., Almost, J., Tuer-Hodes, D. Workplace empowerment and magnet hospital characteristics: making the link. J Nurs Adm. 2003; 33(7-8): 410-22. http://dx.doi.org/10.1097/00005110-200307000-00011
[94] Lake, E. Development of the practice environment scale of the nursing work index. Research in Nursing & Health. 2002; 25(3): 176-88. PMid: 12015780. http://dx.doi.org/10.1002/nur.10032
[95] Maslach, C., Jackson, S., Leiter, M. Maslach Burnout Inventory Manual, 3 edn, Consulting Psychologists Press, Mountain View, California. 1996.

[96] Geurts, S., Taris, T., Kompier, M., Dikkers, J., Van Hooff, M., Kinnunen, U. Work-home interaction from a work psychological perspective: Development and validation of a new questionnaire, the SWING. Work & Stress. 2005; 19(4): 319-39. http://dx.doi.org/10.1080/02678370500410208

[97] Streiner, D.L., Norman, G.R. Health measurement scales: a practical guide to their development and use. Oxford university press. 2008. http://dx.doi.org/10.1093/acprof:oso/9780199231881.001.0001

[98] Warshawsky, N.E., Havens, D.S. Global Use of the Practice Environment Scale of the Nursing Work Index. Nursing Research. 2011; 60(1): 17-31. PMid: 21127450. http://dx.doi.org/10.1097/NNR.0b013e3181ffa79c

[99] Parker, D., Tuckett, A., Eley, R., Hegney, D. Construct validity and reliability of the Practice Environment Scale of the Nursing Work Index for Queensland nurses. International Journal of Nursing Practice. 2010; 16(4): 352-8. PMid: 20649666. http://dx.doi.org/10.1111/j.1440-172X.2010.01851.x

[100] Zhao, P., Chen, F., Hui Jia, X., Lv, H., Cheng, P., Zhang, L. The validation and application of the Chinese version of perceived nursing work environment scale. Journal of Clinical Nursing. 2013; 22(13): 1827-32. PMid: 23647481. http://dx.doi.org/10.1111/jocn.12229

[101] Ogata, Y., Nagano, M., Fukuda, T., Hashimoto, M. Job retention and nursing practice environment of hospital nurses in Japan applying the Japanese version of the Practice Environment Scale of the Nursing Work Index (PES-NWI). Nihon Koshu Eisei Zasshi. 2011; 58(6): 409-19. PMid: 21970075.

[102] Fuentelsaz-Gallego, C., Moreno-Casbas, M., González-María, E. Validation of the Spanish version of the questionnaire Practice Environment Scale of the Nursing Work Index. International Journal of Nursing Studies. 2012; 50(2): 274-80. PMid: 22944284. http://dx.doi.org/10.1016/j.ijnurstu.2012.08.001

[103] Weston, M. Validity of Instruments for Measuring Autonomy and Control Over Nursing Practice. Journal of Nursing Scholarship. 2009; 41(1): 87-94. PMid: 19335682. http://dx.doi.org/10.1111/j.1547-5069.2009.01255.x

[104] Poghosyan, L., Aiken, L., Sloane, D. Factor structure of the Maslach burnout inventory: An analysis of data from large scale cross-sectional surveys of nurses from eight countries. International Journal of Nursing Studies. 2009; 46(7): 894-902. PMid: 19362309. http://dx.doi.org/10.1016/j.ijnurstu.2009.03.004

[105] Bonneterre, V., Liaudy, S., Chatellier, G., Lang, T., De Gaudemaris, R. Reliability, Validity, and Health Issues Arising From Questionnaires Used to Measure Psychosocial and Organizational Work Factors (POWFs) Among Hospital Nurses: A Critical Review. Journal of Nursing Measurement. 2008; 16(3): 207-30. PMid: 19886473. http://dx.doi.org/10.1891/1061-3749.16.3.207

[106] Duffield, C., Roche, M., O'Brien-Pallas, L., Catling-Paull, C., King, M. Staff satisfaction and retention and the role of the Nursing Unit Manager. Collegian (Royal College of Nursing, Australia). 2009; 16(1): 11-7. http://dx.doi.org/10.1016/j.colegn.2008.12.004

[107] Lake, E., McHugh, M. Revision of the Practice Environment Scale of the Nursing Work Index. 25th Academy Health Meeting ed. University of Pennsylvania. Washington. 2008.

[108] Harris, M. Factor Structure of the Practice Environment Scale-Nursing Work Index. Paper presented to the Midwest Nursing Research Society Conference (31st), University of Nebraska. 2007 March 23-26th.

6. Survey instruments

Instrument		Description
Practice Environment Scale - Nurse Work Index	PES-NWI	Consists of 32 Likert type questions including five subscales: 1. nurse participation in hospital affairs (8 questions), 2. nursing foundations for quality of care (9 questions), 3. nurse manager ability, leadership and support of nurses_ (4 questions), 4. staffing and resource adequacy (4 questions), 5. nurse–physician collegiality (7 questions). Scores indicate the extent of agreement that supportive traits are present and can range from 1 (strongly disagree) to 4 (strongly agree), with higher scores indicating a more supportive practice environment. According to (Lake 2002) mean values above 2.5 indicate general agreement, while values below 2.5 indicate disagreement with the characteristics measured by the PES-NWI. (Klopper et al. 2012)
Nurse Work Index-Revised	NWI-R	A 57-item measure of the nurse practice environment developed in the US and used extensively in international research. Nurses indicate their agreement regarding practice environment issues in their current positions on a four-point Likert-type scale anchored by 'strongly disagree' and 'strongly agree. (Gasparino et al. 2011)
Maslach's Burnout Inventory	MBI	Composed of 22 items, evaluated using a Likert scale captures key dimensions of burnout in three subscales: 1. emotional exhaustion, 2. depersonalisation and personal accomplishment. High scores on emotional exhaustion and depersonalisation dimensions and low scores on personal accomplishment dimension are considered indicative of burnout (Aiken et al. 2011).
Conditions of Work Effectiveness Questionnaire	CWEQ II	Includes six subscales reflecting dimensions of empowering structural workplace factors (opportunity, information, support and resources) and sources of power (formal and informal) that enhance access to those factors. The sum of the mean of each subscale forms the variable, total empowerment, representing quality of nursing work environment (Purdy et al 2010).
Nurse Global Satisfaction Questionnaire	NGSQ	Includes overall job satisfaction and satisfaction with co-workers (Purdy et al. 2010)
Nurse-Physician Questionnaire	NPQ	Consists of 47 scales to measure multiple variables affecting relations between nurses and physicians (Manojovich et al. 2008).
Organisational relationship Scale	ORS	Contains 18 items that measure informal power within the work environment. The items are designed to measure perceptions of political alliances, sponsor support, peer networking, and subordinate relationships in the workplace (Cai et al. 2009).
Nurse Working Environment Scale	NWES	A 42-item instrument with seven independent subscales describing the organisational climate regarding: 1. professional practice, 2. staffing and resourcing, 3. nurse management, 4. Nursing process, 5. nurse-physician collaboration, 6. clinical competence, 7. positive scheduling. Nurses are asked to asked to indicate their perception of each item in their working environment by answering strongly disagree (1) to strongly agree (4) on a Likert scale (Stone et al. 2006)

Survey instruments cont'd.

Instrument		Description
Collaboration and Satisfaction About Care Decisions Scale	CSA CDS	Collaboration and Satisfaction About Care Decisions Scale is a 10-item 7-point Likert scale is used to measure nurses' perceptions of the level of collaboration in sharing responsibility for solving problems and making decisions (Papanassoglu et al. 2012
Work Group Characteristics Measure	WG CM	Group processes that are a part of teamwork were assessed using the Work Group Characteristics Measure. Subscale dimensions selected for the present study included task interdependence and process-related group characteristics consisting of potency (team self-efficacy), social support, workload sharing and communication/cooperation (Purdy et al. 2010).
Effort-Reward Imbalance Questionnaire	ERI Q	In the Effort-Reward Imbalance Questionnaire respondents rate their perceived respect from superiors, colleagues and overall respect within the workplace on a seven-point Likert scale. Higher degrees of perceived respect are indicated by higher scores. Overall respect scores are determined by summing and averaging the three items (1–7 range) (Faulkner et al. 2008).
Organizational Culture Inventory	OCI	Organisational Culture Inventory is a 120-item scale, is the most widely used tool for measuring work cultural aspects including the three dimensions of: (1) a team satisfaction–oriented culture, where unit norms emphasize self-expression, achievement, cooperation, and staff development; (2) a security culture, where norms emphasize approval adherence to procedures and conventions, dependence, and avoidance of conflict; and (3) a task security–oriented culture, where unit norms emphasize perfectionism, competition, opposition, and authoritarian control. A team satisfaction–oriented culture is expected to be positively correlated with more effective managerial practices, whereas people security and task security cultures would be negatively associated with the development of effective managerial practices (Minvielle et al. 2005)
Nurses Early Exit Study	NEX T	Nurses Early Exit Study (NEXT-Study) investigated the reasons, circumstances and consequences surrounding premature departure from the nursing profession based on three key areas: (1) job-demand scale assessed by four items related to lack of time to complete work tasks, the ability to pause work when required, pace of work, workload distribution and adequate time to talk to patients; (2) influence at work assessed by four items – nurses say in work tasks, how to fulfil the tasks, work pace and when to fulfil the tasks; and (3) nurse turn over assessed by ascertaining "intent to leave nursing" or "intent to leave the profession in the last year (Hasselhorn et al. 2008).
Copenhagen Psychosocial Questionnaire	CPS OQ	The Copenhagen Psychosocial Questionnaire assesses the psychosocial work environment based upon factors related to work stress, well-being and personality factors.
Nursing Stress Scale	NSS	Nursing Stress Scale is 4-point Likert-type scale—never (0), occasionally (1), frequently (2), and very frequently (3) according to the perceived occurrence based on 34 potentially stressful situations in the workplace including: Workload, death and dying, inadequate preparation, lack of support, uncertainty concerning treatment, conflict with physicians and conflict with other staff.

Survey instruments cont'd.

Instrument		Description
Index of Work Satisfaction	IWS	Consists of ten items that assess the satisfaction from interaction both among nurses and between nurses and physicians including two subscales using a 7-point Likert scale with responses ranging from 1 (''strongly agree'') to 7 (''strongly disagree'') (Manojlovich et al. 2005).
Job Activity Scale	JAS	Contains 12 items that measure the perceived formal power within the work environment. The JAS measures perceptions of job flexibility, discretion, visibility, and recognition within the work environment. The items are summed and averaged to yield a mean score ranging from 1–5 (Cai et al. 2009).
Professional Nursing Autonomy Scale	PNAS	A four point Likert type scale (1 = very unlikely, 4 = very likely) with 35 items measuring role conflict and role ambiguity, and job satisfaction (Iliopoulou et al. 2010)
Practice Environment Questionnaire	PEQ	Measures the four sub constructs of psychological empowerment. Twelve items are rated on a five-point Likert scale ranging from strongly disagree to strongly agree. Items are summed and averaged to yield scores ranging from 1 to 5. Higher degrees of psychological empowerment are indicated by higher scores (Faulkner et al. 2008)
Work Quality Index	WQI	Contains a total of 38 items rated on a Likert scale ranging from 1 to 7; 1 being not satisfied and 7 being satisfied. The index consists of six subscales: professional work environment (eight items), autonomy (five items), work worth (four items), professional relationships (eight items), role enactment (five items), and benefits (eight items) (Lee et al. 2008).
Nursing Work Satisfaction Scale	NWSS	A two part instrument designed to measure nurses' expectations and satisfaction with a range of six job components including autonomy, relationships, work tasks and professional status (Aitken et al. 2010).
Hamilton Anxiety Scale	HAS	Rates the severity of anxiety symptoms according to a scale consisting of 13 items including: anxious mood, tension, fears, sleep disturbances, cognitive disturbances, depressed mood, musculoskeletal symptoms, sensory symptoms, cardiovascular symptoms, respiratory symptoms, gastrointestinal symptoms, genitourinary symptoms, and autonomic nervous system symptoms. The scale ranges from 0 to 4, where zero denotes absence of anxiety symptoms and four indicates very severe symptoms. A total score, calculated by adding the scores assigned to each item, represents the overall anxiety level (Karinikola et al. 2012)
Corley Moral Distress Scale	CMDS	This scale consists of twenty one items describing situations that could engender moral distress. Respondents rate both the frequency and the level of disturbance (intensity) that the situation causes on a scale of zero to four (never occurred/not disturbing) to 4 (occurred very frequently/greatly disturbing). For measuring current level of moral distress, the frequency and intensity scores for each item are multiplied. Each item product of frequency and intensity ranges from 0 to 16. These products are added to obtain a composite score. This scoring scheme allows all items marked as never experienced or not disturbing to be eliminated from the score, reflecting actual moral distress (Papanassoglou et al.2012).

7. Participant information sheet

(Page 1 of 2)

STUDY: EXPLORING THE IMPACT OF ICU ORGANISATIONAL MODELS ON NURSE SATISFACTION AND OUTCOMES (X13-0099)
INFORMATION FOR PARTICIPANTS

Introduction

You are invited to take part in a research study to explore whether the size and organisation of an Intensive Care Unit (ICU) has any impact on the working environment and subsequently on job satisfaction, staff retention and staff turnover.

The impetus for this study is the fact that new and redeveloped ICUs are increasingly adopting the ICU ‘hot-floor’ model, resulting in large capacity ICUs requiring a large clinical workforce. The traditional model ICU of 8-15 beds has given way to ICUs of up to 70 beds being commissioned.

Benefits of the ‘hot-floor’ model are considered to be associated with economies of scale, concentration of resources, reduced duplicity and the potential synergies made possible through the co-location of similar clinical specialities. However, structural changes are required in order to effectively manage operational activity, patient flow, resource utilisation and staffing.

There is however no evidence available on the impact of ICU organisational models on nursing staff outcomes. Study results will inform future revisions of the Australian Health Facility Guidelines for new and redeveloped ICUs, and contribute to the future evolution of intensive care services.

The study is being conducted within this institution by Mr Brett Abbenbroek (PhD candidate) as part of the requirements for a Doctor of Philosophy degree under the supervision of the principle investigators, Professor Christine Duffield (Associate Dean: Research) and Professor Doug Elliott (Professor of Nursing), Faculty of Health, University of Technology, Sydney.

Study Procedures

If you agree to participate in this study, you will be asked to complete a short online questionnaire which will seek information on your perception of your working environment in regard to organisational factors such as supervision, leadership, resourcing and job satisfaction. When you have completed your questionnaire please review your answers to ensure all questions have been answered then select ‘submit completed survey’ to submit online. You will be provided with a confirmation message once submission is complete.

Risks

There are no anticipated risks. The questionnaire is anonymous and will take about 20 minutes to complete.

Benefits

The study aims to inform future revisions of the Australian Health Facility Guidelines for new and redeveloped ICUs, and to contribute to the future evolution of intensive care services.

Costs

Participation in this study will not cost you anything, nor will you be paid.

Voluntary Participation

Participation in this study is entirely voluntary. You do not have to take part in it. If you do take part, you can withdraw at any time up until you submit your survey without having to give a reason.

Confidentiality

All the information collected from you for the study will be treated confidentially, and only the researchers named above will have access to it. The study results may be presented at a conference or in a scientific publication, but individual participants will be anonymous and not identifiable in such a presentation.

Further Information

When you have read this information, Brett Abbenbroek will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact him on mob: 0438 604 713. If you have any further concerns about the study, please contact Professor Christine Duffield, Associate Dean (Research), Faculty of Health, University of Technology, Sydney, by phone: 02 9514 4831 or email: christine.duffield@uts.edu.au. This information sheet is for you to keep.

Ethics Approval and Complaints

This study has been approved by the Ethics Review Committee (RPAH Zone) of the Sydney Local Health District. Any person with concerns or complaints about the conduct of this study should contact the Executive Officer on 02 9515 6766 and quote protocol number X13-0099.

8. Survey Monkey link correspondence

(email extract)

ICU Nurse Survey

To: ICU Nursing DL < NursingDL@[redacted].HEALTH.NSW.GOV.AU>;
Cc: Brett Abbenbroek;

ICU Study ICU Information_For_Participants.pdf99 KB
Show all 1 attachment (99 KB) Download

Hi all,

As mentioned previously an ICU research study to explore whether the size and organisation of an Intensive Care Unit (ICU) has any impact on the working environment and subsequently on job satisfaction, staff retention and staff turnover is being undertaken in ICU by Brett Abbenbroek.

The impetus for this study is the fact that new and redeveloped ICUs are increasingly adopting the ICU 'hot-floor' model, resulting in large capacity ICUs requiring a large clinical workforce. Benefits of the 'hot-floor' model are considered to be associated with economies of scale, concentration of resources, reduced duplicity and the potential synergies made possible through the co-location of similar clinical specialities. Organisational changes are required in order to effectively manage operational activity, patient flow, resource utilisation and staffing. There is no evidence available however on the impact of ICU organisational models on ICU nursing staff outcomes.

Staff information sessions are progressing with Brett through April to June to provide background to the study, answer questions and review the nurse survey instrument that will be used for the study.

You are invited to participate by completing the survey either during the information session on hard copy or electronically via Survey Monkey. Participation is voluntary and anonymous.

Please find attached the Information for Participants brochure.

Please use the following link to complete the survey by June 30th 2014:
https://www.surveymonkey.com/s/ICU_Nurse_Survey

If you have any concerns please do not hesitate to discuss.

Nurse Manager

9. ICU nurse survey instrument

ICU NURSE SURVEY

UNIVERSITY OF TECHNOLOGY SYDNEY
Centre for Health Services Management
PO Box 123, Broadway NSW 2007

To answer please cross in the appropriate box ☒

No: S

A) QUESTIONS ABOUT YOUR WORK LIFE

1. What is your job title?

- Registered Nurse ❑
- Clinical Nurse Specialist ❑
- Clinical Nurse Educator ❑
- Nurse Educator ❑
- Clinical Nurse Consultant ❑
- Nurse Unit Manager ❑
- Nurse Manager ❑

2. How many years have you worked as a Registered Nurse?

- < 1 year ❑
- 1 to 2 years ❑
- 3 to 5 years ❑
- 6 to 10 years ❑
- 11 to 15 years ❑
- 16 to 20 years ❑
- > 20 years ❑

3. How many years have you worked as a Registered Nurse in ICU?

- < 1 year ❑
- 1 to 2 years ❑
- 3 to 5 years ❑
- 6 to 10 years ❑
- 11 to 15 years ❑
- 16 to 20 years ❑
- > 20 years ❑

4. How many years have you worked in *THIS ICU* as a Registered Nurse?

- < 1 year ❑
- 1 to 2 years ❑
- 3 to 5 years ❑
- 6 to 10 years ❑
- 11 to 15 years ❑
- 16 to 20 years ❑
- > 20 years ❑

5. What is your current employment status in this ICU?

- Full time ❑
- Part time 0.8 FTE ❑
- Part time 0.6 FTE ❑
- Part time 0.4 FTE ❑
- Part time 0.2 FTE ❑
- Casual ❑

Other, please specify_______________

6. Do you work a rotating 24 hour roster?

- Yes ❑
- No ❑

UNIVERSITY OF TECHNOLOGY SYDNEY
Centre for Health Services Management
PO Box 123, Broadway NSW 2007

7. In your last work week what shifts did you typically work?

- 12 hour shifts ❑
- 10 hour shifts ❑
- 8 hour shifts ❑
- 10, 8, 8 hour mix of shifts ❑
- Other, please specify________________

8. How would you describe rostering flexibility and ability to request shifts?

- Excellent ❑
- Good ❑
- Fair ❑
- Poor ❑

9. How often are you re-deployed from your (home) ICU to another ward or ICU to work?

- Never ❑
- Rarely (once in 3 months) ❑
- Occasionally (once a month) ❑
- Frequently (twice a month) ❑
- Very frequently (weekly) ❑

10. In your last work week, how many hours *PAID OVERTIME* did you work in your ICU?

- Nil ❑
- $\leq$ 2 hours ❑
- 3 to 5 hours ❑
- 6 to 8 hours ❑
- > 8 hours ❑

11. In your last work week, how many hours *UNPAID OVERTIME* did you work in your ICU?

- Nil ❑
- $\leq$ 2 hours ❑
- 3 to 5 hours ❑
- 6 to 8 hours ❑
- > 8 hours ❑

12. How would you describe accessibility to a Clinical Educator in your ICU?

- Excellent ❑
- Good ❑
- Fair ❑
- Poor ❑

13. How would you describe the level of clinical supervision in your ICU?

- Excellent ❑
- Good ❑
- Fair ❑
- Poor ❑

14. How often are you selected to be a preceptor or mentor for another nurse?

- Never ❑
- Rarely (once a month) ❑
- Occasionally (twice a month) ❑
- Frequently (weekly) ❑
- Very frequently (every 1 to 2 days) ❑

Centre for Health Services Management
PO Box 123, Broadway NSW 2007

15. **How often do nurses come to you for your advice on a clinical issue?**
    - Never ❑
    - Rarely (once a month) ❑
    - Occasionally (twice a month) ❑
    - Frequently (weekly) ❑
    - Very frequently (every 1 to 2 days) ❑

16. **Overall, in the *PAST YEAR*, would you say the quality of patient care in your unit has:**
    - Improved ❑
    - Remained the same ❑
    - Deteriorated ❑
    - I have worked less than 1 year ❑

17. **How would you describe the quality of nursing care delivered on your *LAST ICU SHIFT*?**
    - Excellent ❑
    - Good ❑
    - Fair ❑
    - Poor ❑

18. **How would you describe the level of occupational health and safety in your ICU?**
    - Excellent ❑
    - Good ❑
    - Fair ❑
    - Poor ❑

19. **How would you describe the social cohesion (unity) between nurses in your ICU?**
    - Excellent ❑
    - Good ❑
    - Fair ❑
    - Poor ❑

20. **Do you plan to leave your present nursing job in the next 12 months?**
    - Yes ❑
    - No ❑

21. **Do you plan to move to an ICU in a different hospital in the next 12 months?**
    - Yes ❑
    - No ❑

22. **On the whole, how satisfied are you with your present job?**
    - Very satisfied ❑
    - Moderately satisfied ❑
    - A little dissatisfied ❑
    - Very dissatisfied ❑

23. **Independent of your present job, how satisfied are you with being a nurse?**
    - Very satisfied ❑
    - Moderately satisfied ❑
    - A little dissatisfied ❑
    - Very dissatisfied ❑

ICU NURSE SURVEY

UNIVERSITY OF TECHNOLOGY SYDNEY
Centre for Health Services Management
PO Box 123, Broadway NSW 2007

B) QUESTIONS ABOUT YOU

1. What is your gender?

- Female ❑
- Male ❑

2. What is your age?

- 20 to 24 years ❑
- 25 to 29 years ❑
- 30 to 34 years ❑
- 35 to 39 years ❑
- 40 to 44 years ❑
- 45 to 49 years ❑
- 50 to 54 years ❑
- 55 to 59 years ❑
- > 60 years ❑

3. Do you have an ICU or critical care qualification?

- Yes ❑
- No ❑

4. What is your highest NURSING educational qualification?

- RN Hospital Certificate ❑
- RN Post-Basic Certificate ❑
- RN Diploma ❑
- BScN/BN ❑
- Graduate Certificate ❑
- Graduate Diploma ❑
- Masters Degree ❑
- PhD ❑

5. What is your highest NON-NURSING educational qualification?

- No Qualification ❑
- Diploma ❑
- Bachelors Degree ❑
- Graduate Certificate ❑
- Graduate Diploma ❑
- Masters Degree ❑
- PhD ❑

Centre for Health Services Management
PO Box 123, Broadway NSW 2007

C) THE PRACTICE ENVIRONMENT SCALE (PES)

	For each item in this section, please indicate the extent to which you agree that the following items ARE PRESENT IN YOUR CURRENT JOB.	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree
1	Adequate support services allow me to spend time with my patients.	❑	❑	❑	❑
2	Doctors and nurses have a good working relationship.	❑	❑	❑	❑
3	A supervisory staff that is supportive of the nurses.	❑	❑	❑	❑
4	Active staff development or continuing education programs for nurses.	❑	❑	❑	❑
5	Career development/clinical ladder opportunity.	❑	❑	❑	❑
6	Opportunity for nurses to participate in policy decisions.	❑	❑	❑	❑
7	Supervisors use mistakes as learning opportunities, not criticism	❑	❑	❑	❑
8	Enough time and opportunity to discuss patient care problems with other nurses.	❑	❑	❑	❑
9	Enough registered nurses on staff to provide quality patient care.	❑	❑	❑	❑
10	A nurse manager or immediate supervisor who is a good manager and leader.	❑	❑	❑	❑
11	A senior nursing administrator who is highly visible and accessible to staff.	❑	❑	❑	❑
12	Enough staff to get the work done.	❑	❑	❑	❑
13	Praise and recognition for a job well done.	❑	❑	❑	❑
14	High standards of nursing care are expected by the administration.	❑	❑	❑	❑
15	A senior nursing administrator equal in power and authority to other top level hospital executives.	❑	❑	❑	❑
16	A lot of team work between nurses and doctors.	❑	❑	❑	❑
17	Opportunities for advancement.	❑	❑	❑	❑
18	A clear philosophy of nursing that pervades the patient care environment.	❑	❑	❑	❑
19	Working with nurses who are clinically competent.	❑	❑	❑	❑
20	A nurse manager or supervisor who backs up the nursing staff in decision making, even if the conflict is with a doctor.	❑	❑	❑	❑

UNIVERSITY OF TECHNOLOGY SYDNEY
Centre for Health Services Management
PO Box 123, Broadway NSW 2007

	For each item in this section, please indicate the extent to which you agree that the following items ARE PRESENT IN YOUR CURRENT JOB.	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree
21	Administration that listens and responds to employee concerns.	❑	❑	❑	❑
22	An active quality assurance program.	❑	❑	❑	❑
23	Nurses are involved in the internal governance of the hospital (e.g. practice and policy committees).	❑	❑	❑	❑
24	Collaboration between nurses and doctors.	❑	❑	❑	❑
25	A preceptor program for newly hired nurses.	❑	❑	❑	❑
26	Nursing care is based on a nursing rather than a medical model.	❑	❑	❑	❑
27	Nurses have the opportunity to serve on hospital and nursing committees.	❑	❑	❑	❑
28	Nurse managers consult with staff on daily problems and procedures.	❑	❑	❑	❑
29	Written up-to-date nursing care plans for all patients.	❑	❑	❑	❑
30	Patient care assignments that foster continuity of care (i.e., the same nurse cares for the patient from one day to the next).	❑	❑	❑	❑

D) MASLACH BURNOUT INVENTORY (MBI)

Please read the following statements of job-related feelings and decide if you ever feel this way about *your* job.

If you have *never* had this feeling, select the number "0" (zero). If you have had this feeling, indicate *how often you feel that way* (from *a few times a year or less* "1" to *every day "6"*).

NB. "Recipient" is the patient in your care.

		Never	A few times a year or less	Once a month or less	A few times a month	Once a week	A few times a week	Every day
		0	1	2	3	4	5	6
1.	I feel emotionally drained from my work.	❑	❑	❑	❑	❑	❑	❑
2.	I feel used up at the end of the workday.	❑	❑	❑	❑	❑	❑	❑
3.	I feel fatigued when I get up in the morning and have to face another day on the job.	❑	❑	❑	❑	❑	❑	❑
4.	I can easily understand how my recipients feel about things.	❑	❑	❑	❑	❑	❑	❑
5.	I feel I treat some recipients as if they were impersonal objects.	❑	❑	❑	❑	❑	❑	❑

ICU NURSE SURVEY

UNIVERSITY OF TECHNOLOGY SYDNEY
Centre for Health Services Management
PO Box 123, Broadway NSW 2007

	Never 0	A few times a year or less 1	Once a month or less 2	A few times a month 3	Once a week 4	A few times a week 5	Every day 6
6. Working with people all day is really a strain for me.	❑	❑	❑	❑	❑	❑	❑
7. I deal very effectively with the problems of my recipients.	❑	❑	❑	❑	❑	❑	❑
8. I feel burned out from my work.	❑	❑	❑	❑	❑	❑	❑
9. I feel I'm positively influencing other people's lives through my work.	❑	❑	❑	❑	❑	❑	❑
10. I've become more callous toward people since I took this job.	❑	❑	❑	❑	❑	❑	❑
11. I worry that this job is hardening me emotionally.	❑	❑	❑	❑	❑	❑	❑
12. I feel very energetic.	❑	❑	❑	❑	❑	❑	❑
13. I feel frustrated by my job.	❑	❑	❑	❑	❑	❑	❑
14. I feel I'm working too hard on my job.	❑	❑	❑	❑	❑	❑	❑
15. I don't really care what happens to some recipients.	❑	❑	❑	❑	❑	❑	❑
16. Working with people directly puts too much stress on me.	❑	❑	❑	❑	❑	❑	❑
17. I can easily create a relaxed atmosphere with my recipients.	❑	❑	❑	❑	❑	❑	❑
18. I feel exhilarated after working closely with my recipients.	❑	❑	❑	❑	❑	❑	❑
19. I have accomplished many worthwhile things in this job.	❑	❑	❑	❑	❑	❑	❑
20. I feel like I'm at the end of my rope.	❑	❑	❑	❑	❑	❑	❑
21. In my work, I deal with emotional problems very calmly.	❑	❑	❑	❑	❑	❑	❑
22. I feel recipients blame me for some of their problems.	❑	❑	❑	❑	❑	❑	❑

UNIVERSITY OF TECHNOLOGY SYDNEY
Centre for Health Services Management
PO Box 123, Broadway NSW 2007

E) COMMENTS

1. **Do you have any further comments you would like to make regarding the organisational structure of your ICU?**

Thank you for completing this survey.

10. Data management planning checklist

Element	Item	Description/Detail
Project Overview	Project name	Intensive Care Unit Hot-Floor Study
	Project ID	10229716
	Project website	N/A
	Start date	2010-01-01
	End date	2015-12-31
	Funding source	Nil
	Grant number(s)	N/A
	Activity type	Applied research
	FoR Codes	119999 - Medical and Health Sciences
	SEO Codes	920299 - Health and Support Services
People	Principal	Professor Christine Duffield, FoH UTS
	Investigator/Supervisor	Professor Doug Elliott, FoH UTS
	Study and data Manager	Mr Brett Abbenbroek (Student)
	Clinical Governance ICUA	Prof. Paul Phipps/Mr Paul Hogan
	Clinical Governance ICUB	A/Prof Theresa Jacques/Ms Clare Lovedale
Data Storage	Data file size	< 10GB
	Master storage location	UTS Oxygen Cloud
	Backup during study period	External hard drive password protected Google Cloud (Drive) password protected
	Electronic Survey	Survey Monkey password protected
	Hard copy survey	Transcribed to Excel then scanned to secure file 5
	Data retention period	years post publication
Ethics	UTS Approval Number	2013000014
	Research focus	Involves human subjects
	Sensitivities	Non-public/deidentified
Ownership Licensing & IP	Country data collected	Australia
	IP Owner	Principle Investigator / Study Coordinator
	Copyright	Data owned by NSW Health Ministry
	Data custodians	SLHD, SESLHD & UTS
	Replication	All secondary copies have been securely destroyed
Metadata	Standard used	METeoR: metadata online registry
	Data structure standards	SNOMED & ANZICS APD Data Dictionary
	Data type	Retrospective data from secondary clinical registers (quantitative/deidentified), prospective survey data (quantitative/deidentified)
	Software for data collection	Phillips IntelliSpace Critical Care, GE Centricity Clinical Information System, ANZICS AORTIC Portal, SQL Queries, Survey Monkey and Excel
	Data management /analysis	IBM SPSS V22 & Excel
	Software licensing	UTS

11. SPSS codebook

Patient sample and outcome data (Page 1 of 2)

Full variable name	SPSS variable name	Coding instructions	Measure
HOSPITAL	HOSPITAL	1 = ICUA, 2 = ICUB	Nominal
Patient ID	ID	Record number as per random allocation	Scale
Age	Age	in years and months	Scale
Gender	Gender	0 = Female, 1 = Male	Nominal
Aboriginality	ATSI	0 = non-ATSI, 1 = ATSI	Nominal
Smoking Status Never	Smoking	1 = daily, 2 = weekly, 3 = irregular, 4 = ex-smoker, 5 = never smoked	Nominal
APACHEIII J Score	APACHE_III_J_SCORE	None	Scale
SAPSII Score	SAPSII_SCORE	None	Scale
SAPS Risk of Death	SAPSII_ROD	None	Scale
Intubated	Intubated	0 = no, 1 = yes	Nominal
Ventilated	Ventilated	0 = no, 1 = yes	Nominal
Planned Admissions	Adm_Planned	0 = no, 1 = yes	Nominal
ICU Admission Source	Adm_Source	1 = OT, 2 = ED, 3 = internal transfer, 4 = external transfer	Nominal
Unplanned Extubation	UE	0 = no, 1 = yes	Nominal
CLABSI	CLABSI	0 = no, 1 = yes	Nominal
Pressure Ulcer	PU	0 = no, 1 = yes	Nominal
VTE Prophylaxis	VTEP	0 = no, 1 = yes	Nominal
ICU Mortality	ICU_Mortality	0 = died, 1 = survived	Nominal
ICU LOS Hours	ICU_LoS_Hours	in hours	Scale
After-Hours Discharge	AH_Discharge	0 = no, 1 = yes	Nominal
Discharge Delay Hours	DD_Hours	None	Scale
Discharge Delay > 6hours	DD_6hours	0 = no, 1 = yes	Nominal
Unplanned Readmission < 72 hours	UR	0 = no, 1 = yes	Nominal
ICU Admin Date	ICU_Admin_Date	None	Nominal
ICU Admin Time	ICU_Admin_Time	None	Scale
ICU Discharge Decision Date	ICU_Discharge_Decision_Date	None	Nominal
ICU Discharge Time	ICU_Discharge_Decision	None	Scale
Discharge Date	Discharge_Date	None	Nominal
ICU Discharge Time	ICU_Discharge_Time	None	Scale

Nurse sample and outcome data

Full variable name	SPSS variable name	Coding instructions	Measure
HOSPITAL	HOSPITAL	1 = ICUA, 2 = ICUB	Nominal
Nurse ID	ID	Coded as per survey response	Scale
Job Title	Jon Title	1 = Registered Nurse, 2 = Clinical Nurse Specialist	Nominal
RN_Yrs_Worked	RN_Yrs_Worked	1 = < 1 yr., 2 = 1 to 2 yrs., 3 = 3 to 5 yrs., 4 = 6 to 10 yrs., 5 = 11 to 15 yrs., 6 = 16 to 20 yrs., 7 = > 20yrs.	Nominal
ICU_Yrs_Worked	ICU_Yrs_Worked	1 = < 1 yr., 2 = 1 to 2 yrs., 3 = 3 to 5 yrs., 4 = 6 to 10 yrs., 5 = 11 to 15 yrs., 6 = 16 to 20 yrs., 7 = > 20yrs.	Nominal
This_ICU_Yrs_Worked	This_ICU_Yrs_Worked	1 = < 1 yr., 2 = 1 to 2 yrs., 3 = 3 to 5 yrs., 4 = 6 to 10 yrs., 5 = 11 to 15 yrs., 6 = 16 to 20 yrs., 7 = > 20yrs.	Nominal
Emp_Status	Emp_Status	1 = Full Time, 2 = Part Time	Nominal
Roster	Roster	1 = Roster Rotating 24hours, 2 = Roster Not Rotating	Nominal
Shift_Type	Shift_Type	1 = 12hr, 2 = Mixed 10,8,8	Nominal
Roster_Flexibility	Roster_Flexibility	1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent	Nominal
Redeployed	Redeployed	1 = Never, 2 = Rarely (once mth), 3 = Occasionally (twice mth), 4 = Frequently (weekly), 5 = Very Frequent	Nominal
Paid_OT	Paid_OT	1 = Nil, 2 = Yes	Nominal
Unpaid_OT	Unpaid_OT	1 = Nil, 2 = Yes	Nominal
CNE_Access	CNE_Access	1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent	Nominal
Supervision	Supervision	1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent	Nominal
Mentor	Mentor	1 = Never, 2 = Rarely (once mth), 3 = Occasionally (twice mth), 4 = Frequently (weekly), 5 = Very Frequent	Nominal
Clinical_Advice	Clinical_Advice	1 = Never, 2 = Rarely (once mth), 3 = Occasionally (twice mth), 4 = Frequently (weekly), 5 = Very Frequent	Nominal
Quality_Care	Quality_Care	1 = Worked < 1 yr., 2 = Deteriorated, 3 = Remained the Same, 4 = Improved	Nominal
Quality_Care_Last_Shift	Quality_Care_Last_Shift	1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent	Nominal
OHS	OHS	1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent	Nominal
Social_Cohesion	Social_Cohesion	1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent	Nominal
Will_Resign_Job	Will_Resign_Job	1 = Resign Job, 2 = Not Resign Job	Nominal
Move_ICU	Move_ICU	1 = Move ICU, 2 = Not Move ICUs	Nominal
Job_Satisfaction	Job_Satisfaction	1 = Very Dissatisfied, 2 = A Little Dissatisfied, 3 = Moderately satisfied, 4 = Very Satisfied	Nominal
Nursing_Satisfaction	Nursing_Satisfaction	1 = Very Dissatisfied, 2 = A Little Dissatisfied, 3 = Moderately satisfied, 4 = Very Satisfied	Nominal
Gender	Gender	1 = Female, 2 = Male	Nominal
Age_Yrs	Age_Yrs	1 = 20 to 24, 2 = 25 to 29, 3 = 30 to 34, 4 = 35 to 39, 5 = 40 to 44, 6 = 45 to 49, 7 = 50 to 54, 8 = 55 to 59, 9 = > 60	Nominal
ICU_Qualification	ICU_Qualification	1 = No ICU Qualification, 2 = ICU Qualified	Nominal
Highest_Nurse_Qual	Highes_Nurse_Qual	1 = Undergraduate Nursing, 2 = Postgraduate Nursing,. 3 = Masters Nursing	Nominal
Highest_NonNurse_Qual	Highest_NonNurse_Qual	1 = No Non-Nursing, 2 = Undergraduate Non-Nursing, 3 = Postgraduate Non-Nursing, 4 = Masters Non-Nursing	Nominal
PES-NWI	PES-NWI	P1 – P30	Nominal
MBI	MBI	M1 – M22	Nominal

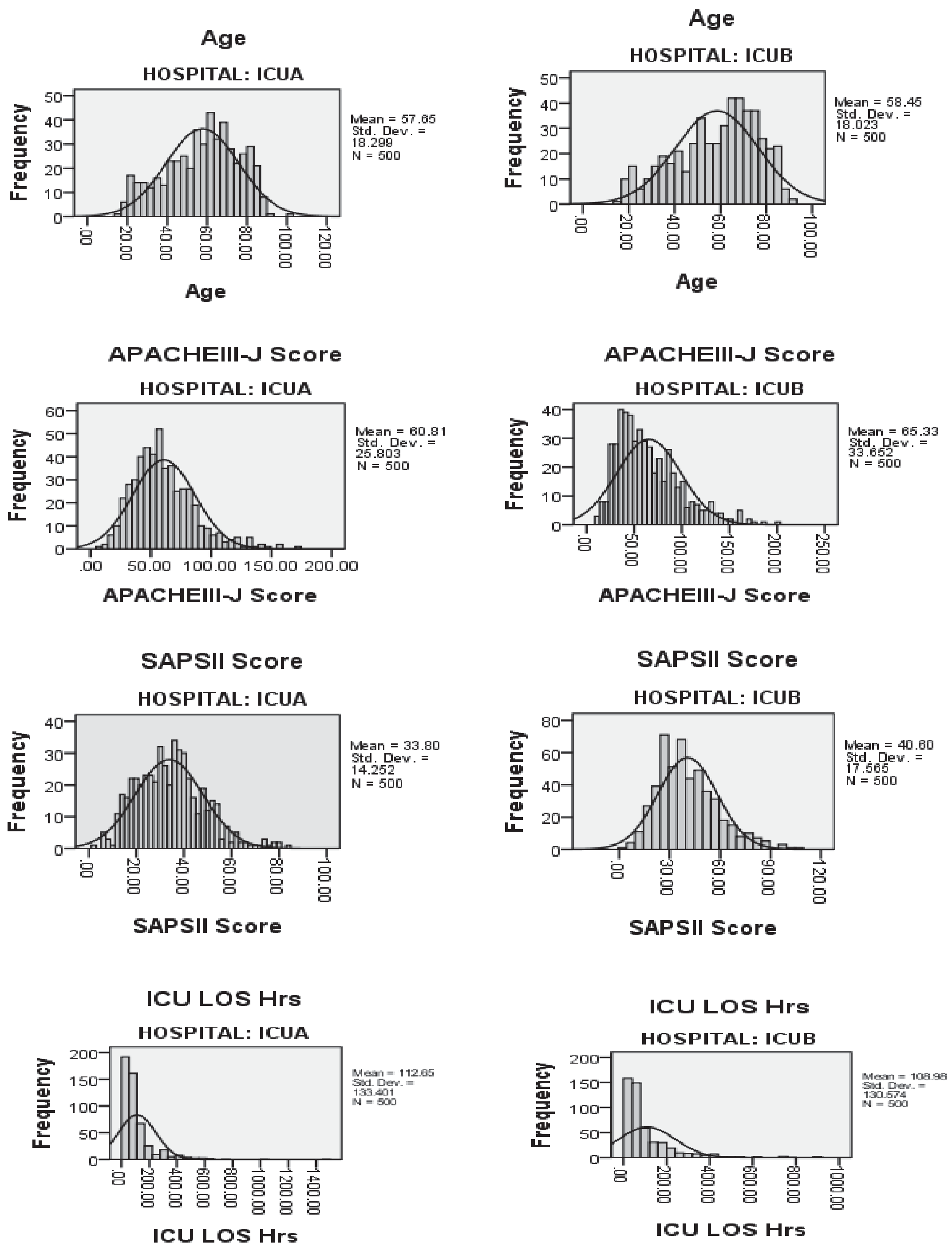
12. Aggregated work and demographic variables

	#	Question	Initial Answer Stratification	Revised Answer Stratification
Nurse Work Questions	1	What is your job title?	Registered Nurse Clinical Nurse Specialist Clinical Nurse Educator Nurse Educator Clinical Nurse Consultant Nurse Unit Manager Nurse Manager	Registered Nurse Clinical Nurse Specialist
	5	What is your current employment status in this ICU?	Full time Part time 0.8 FTE Part time 0.6 FTE Part time 0.4 FTE Part time 0.2 FTE Casual	Full time Part time
	7	In your last work week what shifts did you typically work?	12 hour shifts 10 hour shifts 8 hour shifts 10, 8, 8 hour mix of shifts	12 hour shifts Mixed shifts
	10	In your last work week, how many hours PAID OVERTIME did you work in your ICU?	Nil < 2 hours 3 to 5 hours 6 to 8 hours > 8 hours	Nil Yes
	11	In your last work week, how many hours UNPAID OVERTIME did you work in your ICU?	Nil < 2 hours 3 to 5 hours 6 to 8 hours > 8 hours	Nil Yes
Nurse Demographics	4	What is your highest NURSING educational qualification?	RN Hospital Certificate RN Post-Basic Certificate RN Diploma BScN/BN Graduate Certificate Graduate Diploma Masters Degree PhD	Undergraduate Nursing Postgraduate Nursing Masters Nursing
	5	What is your highest NON-NURSING educational qualification?	No Qualification Diploma Bachelors Degree Graduate Certificate Graduate Diploma Masters Degree PhD	No Non-Nursing Undergraduate Non-Nursing Postgraduate Non-Nursing Masters Non-Nursing

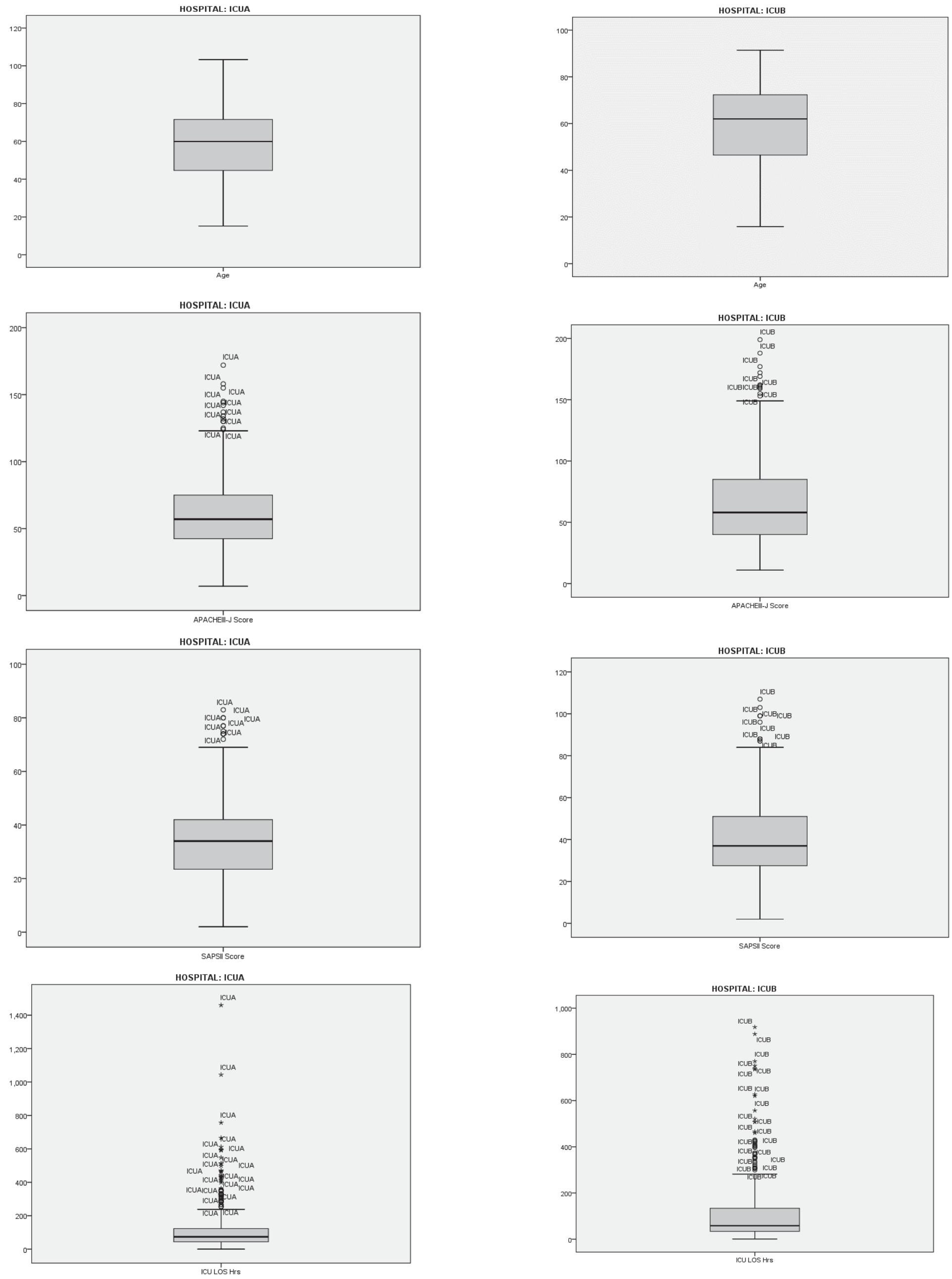
13. Patient sample distribution

(Page 1 of 3)

Histogram distributions for Age, APACHE III-J, SAPSII and LoS in ICUA and ICUB



Boxplot distributions for Age, APACHE III-J, SAPSII and LoS in ICUA and ICUB[6]



[6] SPSS defines an outlier as points that extend more than 1.5 box-lengths form the edge of the box and appear as circles in the graph. Extreme points indicated with an asterix are those that extend more than three box lengths

5% Trimmed Means[7]

	ICUA Mean	5% Trimmed Mean	ICUB Mean	5% Trimmed Mean
Age	57.65	58.03	58.45	59.06
APACHE III-J	60.80	59.02	65.33	63.00
SAPS II	33.80	33.24	39.05	39.68
LoS	112.65	93.64	108.98	90.42

[7] Outliers for Age, APACHE II-J and SAPS II scores had a negligible impact on the mean supporting retention of outliers in the analysis. The influence of extreme values for the LoS variable in both ICUs was strong with an increase in the mean LoS of 19.01 hours in ICUA and 14.56 hours in ICUB. In both samples outliers had a positive influence of a similar magnitude, ICUA = 16.9% vs. ICUB 13.4%, therefore were retained in the analysis

14. Patient sample distribution test results

(Page 1 of 2)

Skewness and kurtosis[8]

Variable	Source	Skewness		Kurtosis	
		Statistic	Std. Error	Statistic	Std. Error
Age (years)	ICUA	-.322	.109	-.686	.218
	ICUB	-.486	.109	-.686	.218
APACHE III-J	ICUA	.982	.109	1.489	.218
	ICUB	1.042	.109	.972	.218
SAPSII	ICUA	.546	.109	.403	.218
	ICUB	.823	.109	.773	.218
Length of Stay (Hours)	ICUA	4.179	.109	27.895	.218
	ICUB	2.851	.109	10.352	.218

Kolmogorov-Smirnov and Shapiro-Wilk[9]

Source		Kolmogorov-Smirnov [1,2]		Shapiro-Wilk [2]	
		Statistic	Sig.	Statistic	Sig.
ICUA	Age	.059	.000	.974	.000
	APACHEIII-J Score	.080	.000	.950	.000
	SAPSII Score	.048	.008	.979	.000
	ICU LOS Hours	.226	.000	.617	.000
ICUB	Age	.089	.000	.961	.000
	APACHEIII-J Score	.098	.000	.929	.000
	SAPSII Score	.083	.000	.960	.000
	ICU LOS Hours	.211	.000	.679	.000

---

[8] Skewness and kurtosis results based on analysis of standard errors

[9] All continuous variables differed significantly from a normal distribution based on the Kolmogorov-Smirnov test and examination of the normal probability plots (Normal Q-Q Plot) which did not conform to a reasonably straight line.

Summary of normality test results[10]

Variable	Test	ICUA	ICUB
Age	Histogram	Unimodal symmetrical	Unimodal Symmetrical
	Boxplot	Nil outliers	Nil outliers
	5% Trimmed mean	< 1 standard deviation	< 1 standard deviation
	Skewness	Symmetrical	Symmetrical
	Kurtosis	Approx. normality	Approx. normality
	Kolmogorov-Smirnov	$p < 0.00$	$P < 0.00$
	Normal Q-Q plot	Low correlation	Low correlation
APACHE III-J	Histogram	Unimodal positive skew	Unimodal positive skew
	Boxplot	Outliers	Outliers
	5% Trimmed mean	< 1 standard deviation	< 1 standard deviation
	Skewness	Moderate	Moderate
	Kurtosis	Approx. normality	Approx. normality
	Kolmogorov-Smirnov	$p < 0.00$	$P < 0.00$
	Normal Q-Q plot	Low correlation	Low correlation
SAPSII	Histogram	Unimodal positive skew	Unimodal positive skew
	Boxplot	Outliers	Outliers
	5% Trimmed mean	< 1 standard deviation	< 1 standard deviation
	Skewness	Moderate	Moderate
	Kurtosis	Approx. normality	Approx. normality
	Kolmogorov-Smirnov	$p < 0.08$	$P < 0.00$
	Normal Q-Q plot	Low correlation	Low correlation
LoS	Histogram	Unimodal positive skew	Unimodal positive skew
	Boxplot	Far outliers	Far outliers
	5% Trimmed mean	< 1 standard deviation	< 1 standard deviation
	Skewness	High	High
	Kurtosis	Highly anomalous	Highly anomalous
	Kolmogorov-Smirnov	$p < 0.00$	$P < 0.00$
	Normal Q-Q plot	Low correlation	Low correlation

[10] Tests confirmed that the four continuous variables were skewed confirming the known heterogeneity of the ICU patient population. Variables ranged from moderately to highly positively skewed justifying the need to undertake data transformation to determine appropriate parametric or non-parametric tests (Tabachnick & Fidell 2013).

15. Patient data transformation and distribution[11]

Variable	Source	Histogram	Outliers	Skewness	Kurtosis	KS[1]	SW[2]
Age	ICUA	Symmetrical	nil	-.322	-.686	.000	.000
	ICUB	Symmetrical	nil	-.486	-.686	.000	.000
Age_SQRT	ICUA	-ve skew	Yes	-.663	-.282	.000	.000
	ICUB	-ve skew	Yes	-.817	-.069	.000	.000
Age_LG10	ICUA	-ve skew	Yes	-1.043	.508	.000	.000
	ICUB	-ve skew	Yes	-1.202	.914	.000	.000
APACHE II-J	ICUA	+ve skew	Yes	.982	1.489	.000	.000
	ICUB	+ve skew	Yes	1.042	.972	.000	.000
APACHEIIIJ_SQRT	ICUA	+ve skew	Yes	.342	.287	.069	.033
	ICUB	+ve skew	Yes	.442	-.165	.000	.000
APACHEIIIJ_LG10	ICUA	+ve skew	Yes	-.515	1.091	.010	.000
	ICUB	+ve skew	Yes	-.212	-.123	.160	.028
SAPSII	ICUA	+ve skew	Yes	.546	.403	.008	.000
	ICUB	+ve skew	Yes	.823	.773	.000	.000
SAPSII_SQRT	ICUA	Symmetrical	Yes	-.119	.218	.002	.173
	ICUB	Symmetrical	Yes	.165	.155	.028	.131
SAPSII_LG10	ICUA	-ve skew	Yes	-1.043	2.49	.000	.000
	ICUB	-ve skew	Yes	-.844	2.960	.005	.000
LoS	ICUA	+ve skew	Far	4.179	27.89	.000	.000
	ICUB	+ve skew	Far	2.851	10.35	.000	.000
LoS_SQRT	ICUA	+ve skew	Far	1.746	4.890	.000	.000
	ICUB	+ve skew	Far	1.420	2.259	.000	.000
LoS_LOG10	ICUA	+ve skew	Far	.024	.586	.021	.014
	ICUB	+ve skew	Far	-.141	.844	.007	.000

Notes: 1. Kolmogorov-Smirnov (Lilliefors Significance Correction)
2. Shapiro-Wilk

[11] Positively highly skewed data with no zeros or negative numbers require a square root or log transformation. Both square-root (SQRT) and logarithmic (LG10) transformations were performed for completeness (Pallant 2013). Results were then compared by visual distribution of newly generated histograms and comparison of skewness and kurtosis values with the original analysis. Following data transformation the distribution was no more normal than the original variables. Age became less symmetrical, developed outliers and had worsening skewness with a slight improvement in kurtosis. The distribution of APACHE III-J and SAPSII scores did not benefit from either transformation method. Improved LoS distribution in terms of skewness and kurtosis scores was achieved from for both transformations, however, positively skewed data and far outliers persisted.

16. ICU service characteristics

	Attribute	ICUA	ICUB	National [1,2]
Service Classification	Hospital type, beds	Public, 700	Public, 650	Public, UA [3]
	Hospital classification	Adult Tertiary	Adult Tertiary	Adult Tertiary
	ICU type	General	General	General
	ICU organisational model	**Hot-floor** [4]	**Conventional** [5]	**Hot-floor** (8.0%)
	Functional ICU level (CICM)	3	3	3
	Training accreditation level	C24	C24	C24 (95%)
Clinical specialties	Tertiary Major Trauma	✓	✓	UA
	Tertiary Spinal Injury	X	X	UA
	Tertiary Severe Burns	X	X	UA
	Cardiac surgery	✓	✓	UA
	Neurosurgery	✓	✓	UA
	Transplant (exc. Kidney)	✓	X	UA
	ECMO (resp. support)	✓	✓	UA
Hospital Support	Rapid response team	✓	✓	UA
	Discharge review/nurse liaison	✓	✓	UA
	Total parenteral nutrition (TPN)	✓	✓	UA
	Venous access service	✓	✓	UA
	Tracheostomy service	✓	✓	UA
Standardised Clinical Processes	Airway management competency	✓	✓	✓
	Percutaneous tracheal competency	✓	✓	✓
	Central line insertion competency	✓	✓	✓
	Ultrasound competency	✓	✓	✓
	Process checklists (e.g. FASTHUG)	✓	✓	✓
	Pharmacist rounds	✓	✓	✓
	Microbiologist rounds	✓	✓	✓
	Antibiotic stewardship/anti-biograms	✓	✓	✓
Centrally Reported Quality Activities	CLABSI rates	✓	✓	✓
	VTEP and VTE rates	✓	✓	✓
	MRSA rates	✓	✓	✓
	Pressure ulcer risk assessment / rates	✓	✓	UA
	Medication error rates	✓	✓	✓
	Adverse incident rates	✓	✓	✓
	Mortality reviews and rates	✓	✓	UA
	Patient / family satisfaction surveys	✓	✓	UA

Notes:
1. Source (ANZICS CORE 2014)
2. N = 31 tertiary adult ICU's
3. UA = Unavailable
4. Hot-floor = GICU nested in a multispecialty service
5. Conventional standalone unit

17. ICU workforce structures

	Staffing Attribute	ICU A Hot-floor	ICU B Traditional
Nursing	Nurse Manager	✓	✓
	Nurse Unit Manager	✓	✓
	Nurse Unit Manager (After-Hours)	✓	✓
	Team Leader/ACCESS Nurse	✓	✓
	Clinical Information System Manager	✓	✓
	Equipment Manager	✓	✓
	Research/Data Manager	✓	✓
	Clinical Nurse Consultant	✓	✓
	Nurse Educator	X	✓
	Clinical Nurse Educator	✓	✓
	Clinical Bedside Nurse	✓	✓
Medical	Medical Director	✓	✓
	Deputy Director	X	✓
	Staff Specialist/VMO	✓	✓
	Senior Registrar/Registrar	✓	✓
	Junior Registrar/RMO	✓	✓
	Rapid Response Team	✓	✓
Allied	ICU Snr. Physiotherapist	✓	✓
	ICU Pharmacist	✓	✓
	Ancillary / Orderly	✓	✓
	Clerical	✓	✓

Notes:
1. Source (ANZICS CORE 2014)
2. N = 31 tertiary adult ICU's
3. UA = Unavailable
4. Hot-floor = GICU nested in a multispecialty service
5. Conventional standalone unit

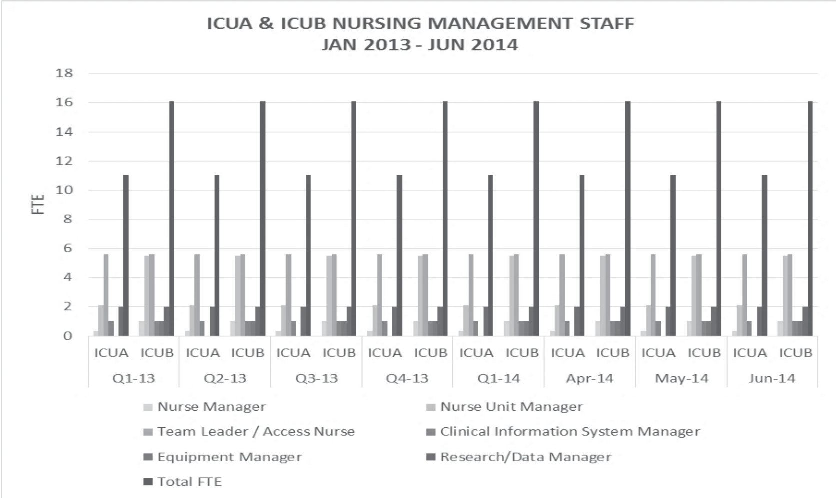
18. ICU workforce snapshot May 2014

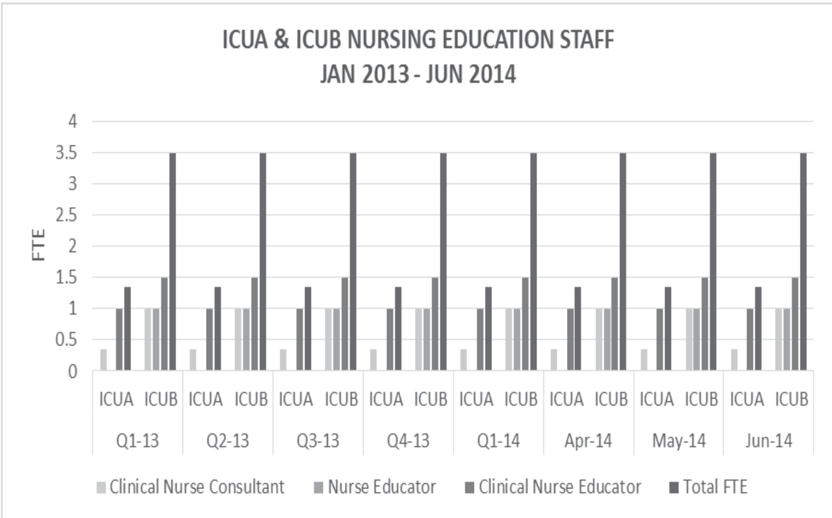
	Organisational Attribute	ICU A Hot-floor 17 beds		ICU B Traditional 15 beds		Chi-Square[1] χ^2	α [2]	ICR [3] μ 16 beds
Nursing Staff (FTE)	Target Establishment (FTE)	113.7	6.7/bed	103.6	6.9/bed			μ = 110.32/ 6.27 bed
	Nursing Actual (FTE)	(n)	%	(n)	%			
	Management	11.0	9.71	16.01	15.5			
	Education	1.35	1.22	3.51	3.39			
	Clinical	100.8	88.8	84.0	81.1			
	Clinical Nurse Specialist	13.80	13.7	10.6	12.6	1.29	.197	
	RN Years 7-8	17.90	17.7	10.8	12.9	1.11	.267	
	RN Years 5-6	13.60	13.5	7.60	9.10	1.76	.078	
	RN Years 3-4	35.28	35.0	24.6	29.2	3.81	.001	
	RN Years 1-2	19.50	19.4	30.4	36.2	-6.47	.001	
	Active clinical vacancies	2.0	2.10	5	4.20			
	Qualified nursing staff		43		49			μ = 51%
	Shift Staffing (FTE)	BH [4]	AH [4]	BH	AH			
	Nurse Manager	0.35	0	1	0			
	Nurse Unit Manager	1	0.35	1	1			
	Team Leader/ACCESS Nurse	0	1	0	1			
	Clinical Nurse Consultant	0.35	0	1	0			
	Nurse Educator	0	0	1	0			
	Clinical Nurse Educator	1	0	1	0			
	Clinical Bedside	17	17	15	15			
Medical Staff (FTE)	Medical Actual (FTE)	17.8	1.1/bed	33.8	2.3/bed			μ = 24.05/ 1.50 bed
	Management	0.35		1				μ = 1
	Clinical Staff Specialist	4.1		9.8				μ = 7.57
	Clinical Senior Registrars	4.6		6				μ = 3.53
	Clinical Registrar/Residents	8.75		18				μ = 11.95
	Shift Staffing (FTE)	BH	AH	BH	AH			
	Medical Director	0.35	0	0.5	0			
	Deputy Director	0	0	0.5	0			
	Staff Specialist/VMO	1	0.83	1	1			
	Senior Registrar/Registrar	2	1	2	1			
	Junior Registrar/RMO	2	2	1	1			
	Rapid Response Team	1	1	0.5	0			
	Staff Specialist per patient[5]	5.9%	4.9%	6.7%	6.7%			
Allied Staff (FTE)	ICU Snr. Physiotherapist	1.5		1				
	ICU Pharmacist	0.35		1				
	Ancillary / Orderly	1.35		3				
	Clerical	1.7		1.5				
	Allied Shift Staffing	BH	AH	BH	AH			
	ICU Snr. Physiotherapist	1.5	On call	1	On call			
	ICU Pharmacist	0.35	On call	1	On call			
	Ancillary / Orderly	1	0.35	2	1			
	Clerical	1.35	0.35	1	0.5			

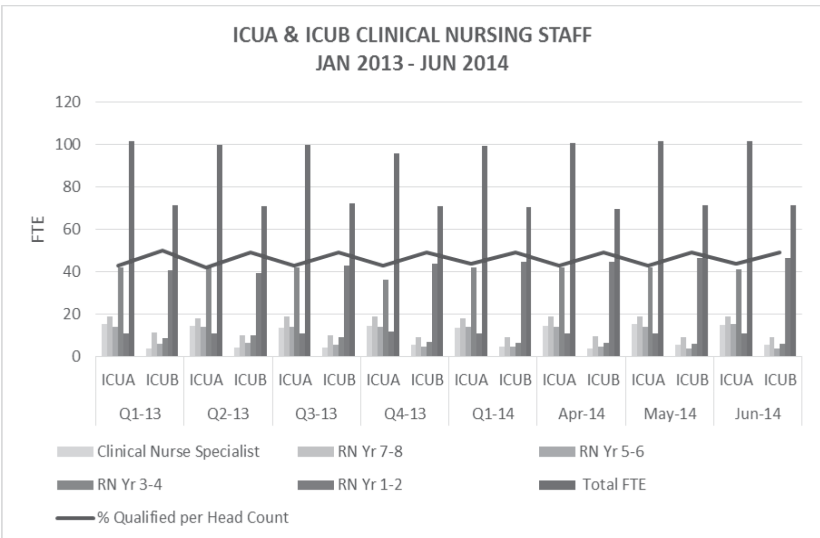
Notes:
1. df = 1
2. α = < 0.05
3. Source (ANZICS 2014)
4. BH - Business hours = Mon to Fri (8am to 6pm); AH – After-Hours (6.01pm to 7.59 am)
5. Percentage of time with each patient on the daily ward round

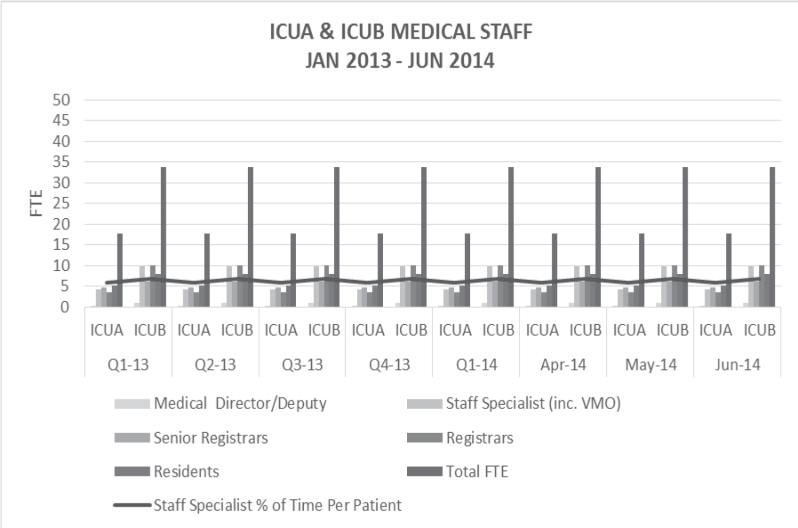
19. Workforce stability

(Page 1of 3)

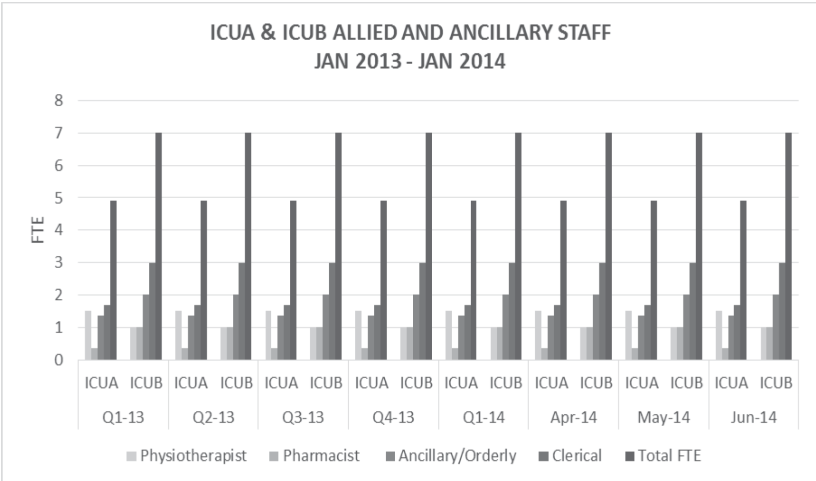




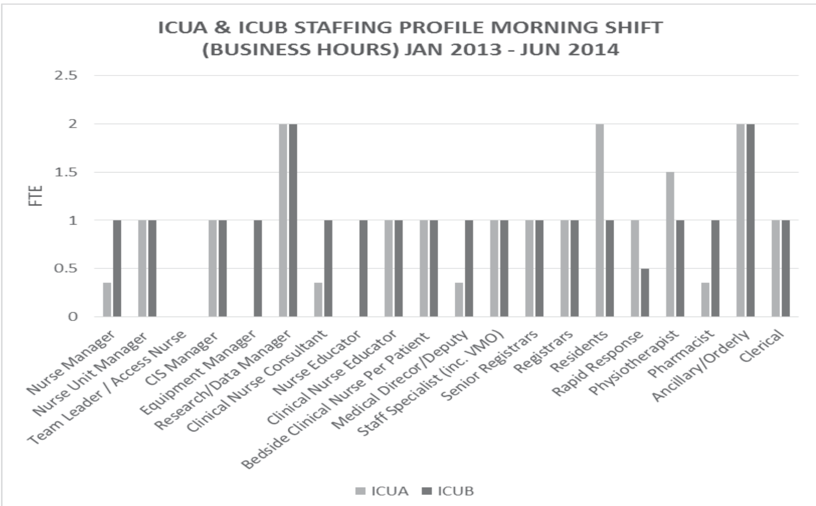




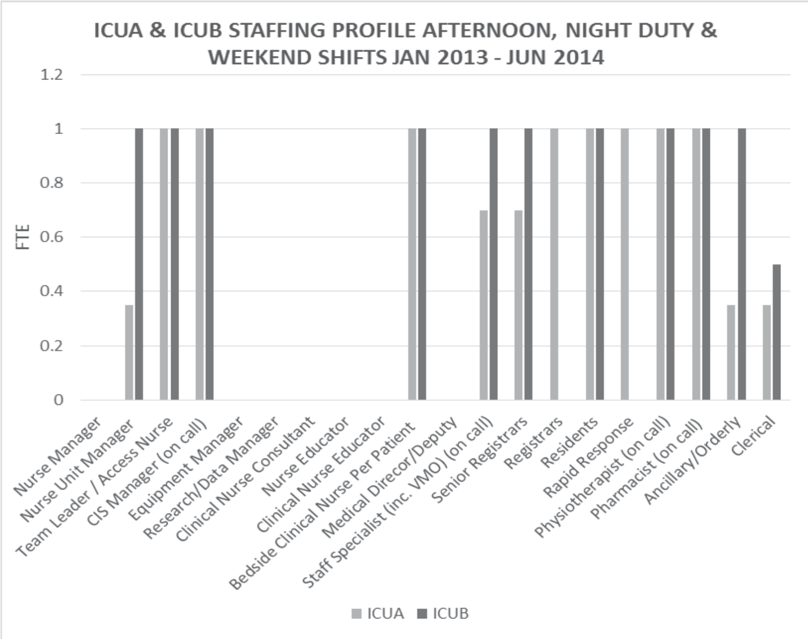
ICUA & ICUB MEDICAL STAFF
JAN 2013 - JUN 2014
FTE
0
5
10
15
20
25
30
35
40
45
50
ICUA
ICUB
Q1-13
Q2-13
Q3-13
Q4-13
Q1-14
Apr-14
May-14
Jun-14
Medical Director/Deputy
Staff Specialist (inc. VMO)
Senior Registrars
Registrars
Residents
Total FTE
Staff Specialist % of Time Per Patient



ICUA & ICUB ALLIED AND ANCILLARY STAFF
JAN 2013 - JAN 2014
FTE
0
1
2
3
4
5
6
7
8
ICUA
ICUB
Q1-13
Q2-13
Q3-13
Q4-13
Q1-14
Apr-14
May-14
Jun-14
Physiotherapist
Pharmacist
Ancillary/Orderly
Clerical
Total FTE



ICUA & ICUB STAFFING PROFILE MORNING SHIFT
(BUSINESS HOURS) JAN 2013 - JUN 2014
FTE
0
0.5
1
1.5
2
2.5
Nurse Manager
Nurse Unit Manager
Team Leader / Access Nurse
CIS Manager
Equipment Manager
Research/Data Manager
Clinical Nurse Consultant
Nurse Educator
Clinical Nurse Educator
Bedside Clinical Nurse Per Patient
Medical Direcor/Deputy
Staff Specialist (inc. VMO)
Senior Registrars
Registrars
Residents
Rapid Response
Physiotherapist
Pharmacist
Ancillary/Orderly
Clerical
ICUA
ICUB



ICUA & ICUB STAFFING PROFILE AFTERNOON, NIGHT DUTY & WEEKEND SHIFTS JAN 2013 - JUN 2014
1.2
1
0.8
0.6
0.4
0.2
0
FTE
Nurse Manager
Nurse Unit Manager
Team Leader / Access Nurse
CIS Manager (on call)
Equipment Manager
Research/Data Manager
Clinical Nurse Consultant
Nurse Educator
Clinical Nurse Educator
Bedside Clinical Nurse Per Patient
Medical Direcor/Deputy
Staff Specialist (inc. VMO) (on call)
Senior Registrars
Registrars
Residents
Rapid Response
Physiotherapist (on call)
Pharmacist (on call)
Ancillary/Orderly
Clerical
ICUA
ICUB

20. Patient sample correlation analysis

Results from Spearman’s rho of patient characteristics and severity [12,13]

	Variable		Age	APACHE III-J Score	SAPSII Score	ICU LOS Hours
ICUA[1]	Age	Correlation Coefficient	1.00	.435**	.460**	.134**
		Sig. (2-tailed)[2]	.	.000	.000	.003
	APACHEIII-J Score	Correlation Coefficient	.435**	1.00	.846**	.363**
		Sig. (2-tailed)	.000	.	.000	.000
	SAPSII Score	Correlation Coefficient	.460**	.846**	1.00	.390**
		Sig. (2-tailed)	.000	.000	.	.000
	ICU LOS Hours	Correlation Coefficient	.134**	.363**	.390**	1.00
		Sig. (2-tailed)	.003	.000	.000	.
ICUB[1]	Age	Correlation Coefficient	1.00	.397**	.429**	.003
		Sig. (2-tailed)	.	.000	.000	.950
	APACHEIII-J Score	Correlation Coefficient	.397**	1.00	.872**	.000
		Sig. (2-tailed)	.000	.	.000	.998
	SAPSII Score	Correlation Coefficient	.429**	.872**	1.00	-.020
		Sig. (2-tailed)	.000	.000	.	.660
	ICU LOS Hours	Correlation Coefficient	.003	.000	-.020	1.00
		Sig. (2-tailed)	.950	.998	.660	.

Notes:
1. All variable sample sizes = 500 patients
2. α = < 0.05
3. ** Significant at α = <0.01 (2-tailed)

Test of difference between two independent correlation coefficients[14]

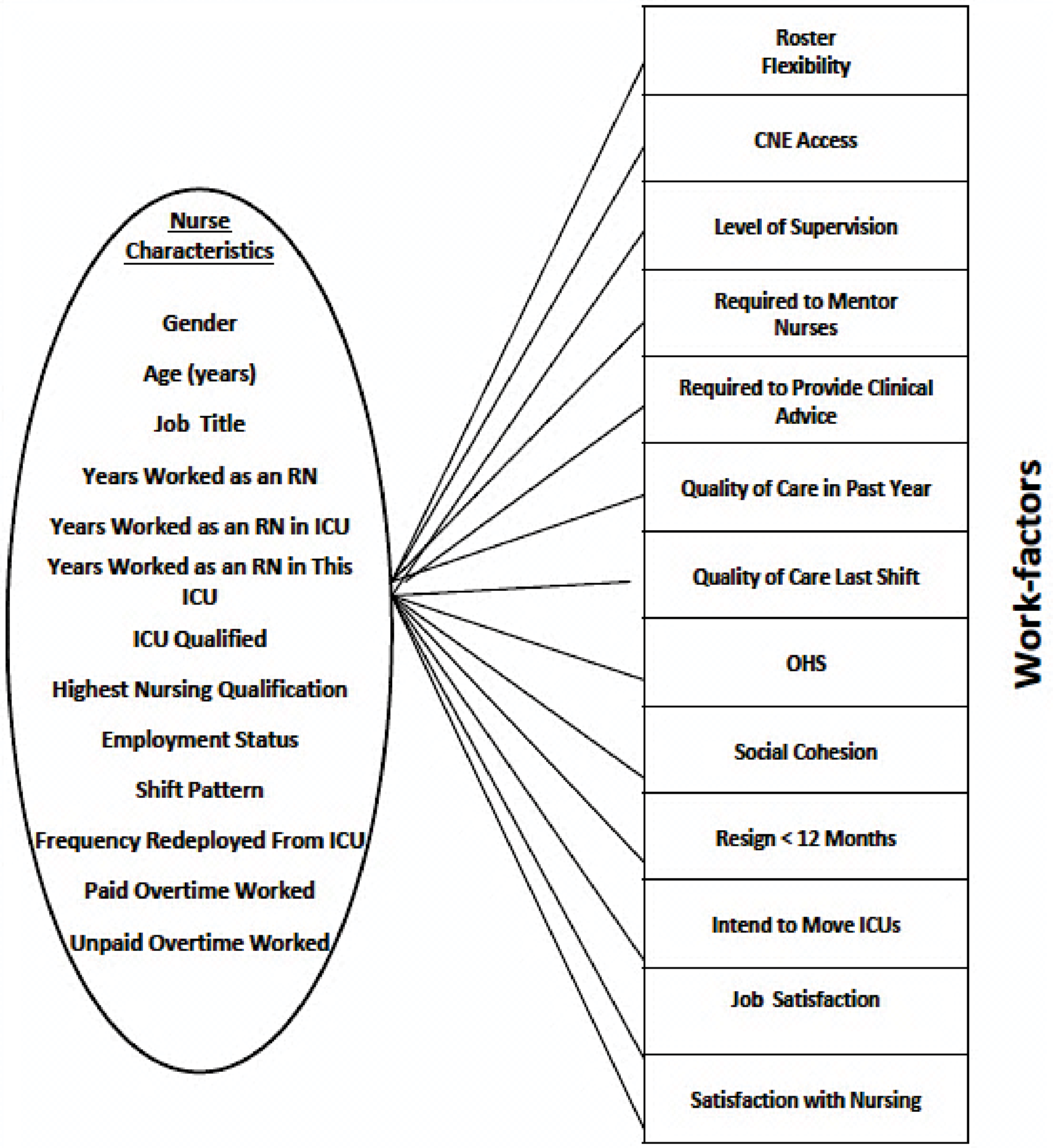
Variable	R	Source	Age	Z[a]	One tail p	Two tail p	APACHE III-J Score	Z	One tail p	Two tail p	SAPS II Score	Z	One tail p	Two tail p
APACHE III-J Score	r_1	ICUA	.435	.725	.234	.468								
	r_2	ICUB	.397											
SAPSII Score	r_3	ICUA	.460	.609	.271	.542	.846	-1.57	.058	.117				
	r_4	ICUB	.429				.872							
ICU LOS Hours.	r_5	ICUA	.134	2.08	.019	.038	.363	6.00	0.00	0.00	.390	6.81	0.00	0.00
	r_6	ICUB	.003				.000				-.020			

[12] Scatterplots for each sample confirmed weak linearity and the assumption of homoscedasticity was upheld.

[13] A moderate positive relationship was confirmed between age and APACHE III-J, and SAPS II scores in both patient samples, and age and LoS in ICUA.[13] A strong positive correlation was also confirmed between APACHE III-J and SAPS II scores in both ICUs. Conversely, only ICUA had a moderate positive correlation between LoS and APACHE III-J, and LoS and SAPS II scores.

[14] Coefficients were converted to a z-score using Fisher's r-to-z transformation then compared using formula 2.8.5 from Cohen & Cohen (1983, p. 54). Conversion for the calculation to test the difference between two independent correlation coefficients was achieved using an online interactive calculator (. source http://www.quantpsy.org/corrtest/corrtest.htm) as IBM SPSS 22 did not possess this function (Preacher 2002). The resulting z-scores were compared in a 1-tailed and 2-tailed method to the unit normal distribution. By convention, values greater than - 1.96 or + 1.9 are considered significant if a 2-tailed test is performed. Where r1 is greater than r2 the resulting value of z will be positive or if smaller then z will be negative (Preacher 2002).

21. Model for within nurse groups analysis



22. Results for within groups Pearson's Chi-square analysis

(Page 1 of 2)

Hot-floor	Roster Flexibility	CNE Access	Level of Supervision	Mentor Nurses	Provide Clinical Advice	Quality of Care in Past Year	Quality of Care Last Shift	OHS	Social Cohesion	Resign < 12 Months	Intend to Move ICUs	Job Satisfaction	Satisfaction with Nursing
Age (years)												34.9_{21} 0.029	54.8_{21} 0.00
Job Title			11.6_{2} 0.003		13.4_{4} 0.009								11.4 0.010
Years Worked as an RN					55.8_{24} 0.00	39.9_{18} 0.002						39.8_{18} 0.002	31.4_{18} 0.026
Years Worked as an RN in ICU			22.8_{12} 0.029		64.4_{24} 0.00	55.9_{18} 0.00							
Years Worked in This ICU		18.4_{10} 0.049	21.1_{10} 0.020		47.8_{20} 0.00	43.0_{15} 0.00							
ICU Qualified													
Highest Nursing Qual.													
Highest Non Nursing Qual.			15.3_{6} 0.018										
Employment Status													11.7_{3} 0.009
Shift Pattern					14.1_{4} 0.007	20.4_{3} 0.000				12.0_{3} 0.007			
Frequency Redeployed					32.4_{16} 0.009					9.7_{4} 0.046		24.5_{12} 0.018	
Paid Overtime Worked													
Unpaid Overtime Worked			6.9_{2} 0.031									16.5_{3} 0.001	

Notes: 1. Significant associations reported as (χ^2_{df}, α)
2. α = < 0.05 Asymptotic Sig (2 sided),
3. Yates continuity correction

Conventional ICU	Roster Flexibility	CNE Access	Level of Supervision	Mentor Nurses	Provide Clinical Advice	Quality of Care in Past Year	Quality of Care Last Shift	OHS	Social Cohesion	Resign < 12 Months	Intend to Move ICUs	Job Satisfaction	Satisfaction with Nursing
Age (years)					40.3_{24} 0.02	37.5_{18} 0.005							
Job Title					22.6_{4} 0.000				8.9_{3} 0.03			6.4_{2} 0.04	
Years Worked as an RN					51.2_{24} 0.001	53.8_{18} 0.00				17.7_{6} 0.001	14.9_{6} 0.02		
Years Worked as an RN in ICU					51.9_{20} 0.00	46.5_{15} 0.00							
Years Worked in This ICU				22.8_{12} 0.030	43.0_{16} 0.00	37.2_{12} 0.00				12.2_{4} 0.016			
ICU Qualified				8.4_{3} 0.039	17.1_{4} 0.002	10.4_{3} 0.016							
Highest Nursing Qual.	12.7_{6} 0.048	14.0_{4} 0.007			20.3_{8} 0.009	12.5_{6} 0.051							10.8_{4} 0.029
Highest Non Nursing Qual.								15.2_{6} 0.019					
Employment Status						8.3 3: 0.030							5.9_{2} 0.06
Shift Pattern						10.2_{6} 0.017		6.6_{6} 0.038					
Frequency Redeployed	23.9_{12} 0.021					51.0_{12} 0.00							
Paid Overtime Worked													
Unpaid Overtime Worked	8.0_{3} 0.047				10.9_{4} 0.028				10.0_{3} 0.018	5.1^{3}_{1} 0.24	12.8^{3}_{1} 0.00	7.7_{2} 0.021	

Notes:
1. Significant associations reported as (χ^2_{df}, α)
2. α = < 0.05 Asymptotic Sig (2 sided),
3. Yates continuity correction

23. Principal component analysis

(Page 1 of 2)

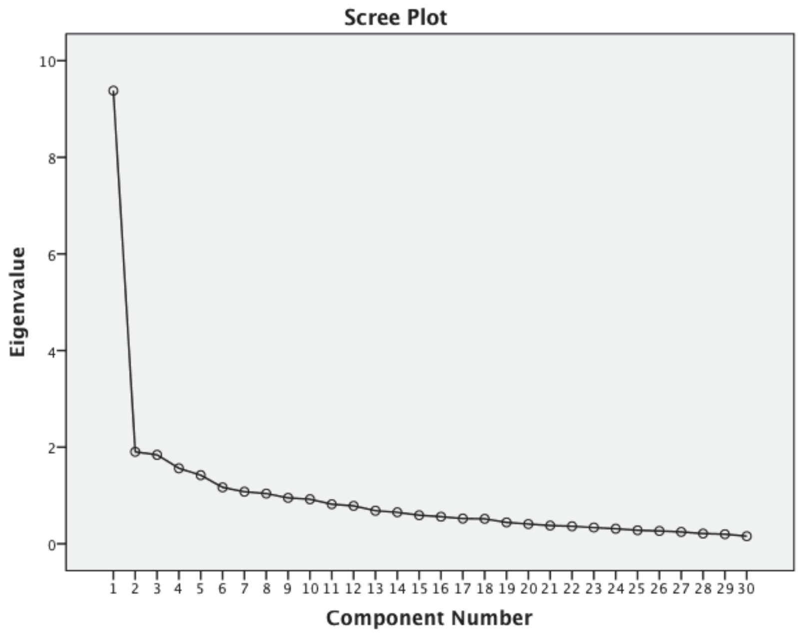
PES-NWI correlation matrix

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30
1	1.000																													
P2	.287	1.000																												
P3	.261	.279	1.000																											
P4	.302	.317	.335	1.000																										
P5	.233	.288	.343	.563	1.000																									
P6	.210	.243	.303	.450	.429	1.000																								
P7	.255	.348	.393	.411	.416	.506	1.000																							
P8	.383	.165	.105	.137	.260	.142	.288	1.000																						
P9	.330	.306	.166	.306	.253	.221	.283	.296	1.000																					
P10	.265	.205	.151	.444	.328	.424	.458	.112	.120	1.000																				
P11	.243	.291	.231	.315	.178	.316	.362	.174	.178	.448	1.000																			
P12	.421	.210	.232	.349	.260	.135	.206	.375	.655	.163	.297	1.000																		
P13	.474	.359	.323	.525	.471	.375	.441	.297	.313	.518	.309	.394	1.000																	
P14	.390	.188	.249	.250	.232	.191	.215	.302	.192	.099	.107	.213	.299	1.000																
P15	.280	.285	.204	.379	.353	.275	.349	.418	.324	.254	.316	.378	.365	.378	1.000															
P16	.349	.552	.326	.231	.330	.175	.306	.275	.313	.146	.216	.230	.369	.281	.353	1.000														
P17	.301	.353	.201	.438	.624	.406	.400	.289	.268	.398	.368	.245	.474	.246	.311	.448	1.000													
P18	.252	.220	.333	.391	.381	.237	.218	.277	.374	.190	.182	.444	.468	.332	.359	.364	.406	1.000												
P19	.189	.366	.308	.396	.284	.118	.320	.243	.381	.151	.199	.397	.322	.367	.338	.488	.288	.416	1.000											
P20	.306	.321	.273	.428	.324	.418	.471	.237	.287	.451	.336	.219	.374	.328	.398	.263	.355	.276	.350	1.000										
P21	.284	.465	.224	.448	.359	.332	.431	.148	.363	.376	.458	.335	.397	.137	.445	.391	.465	.327	.428	.365	1.000									
P22	.288	.243	.191	.239	.231	.333	.375	.167	.341	.280	.140	.220	.415	.207	.328	.282	.273	.323	.219	.314	.435	1.000								
P23	.316	.074	.189	.274	.333	.433	.296	.206	.230	.163	.131	.098	.312	.195	.273	.215	.239	.292	.120	.212	.314	.449	1.000							
P24	.220	.531	.307	.233	.294	.219	.229	.159	.265	.146	.257	.152	.251	.159	.211	.564	.392	.254	.385	.279	.446	.378	.280	1.000						
P25	.302	.145	.180	.321	.222	.289	.181	.151	.210	.282	.264	.128	.226	.317	.213	.175	.166	.208	.316	.333	.205	.410	.387	.288	1.000					
P26	.260	.206	.311	.131	.086	.223	.345	.260	.167	.165	.218	.111	.203	.260	.248	.229	.163	.258	.297	.359	.334	.401	.287	.382	.313	1.000				
P27	.235	.253	.242	.164	.360	.326	.201	.247	.100	.136	.170	.087	.314	.303	.289	.362	.327	.333	.186	.227	.270	.483	.548	.315	.438	.379	1.000			
P28	.253	.319	.189	.345	.327	.360	.371	.287	.233	.407	.319	.115	.412	.262	.313	.282	.332	.215	.343	.460	.482	.389	.310	.390	.372	.416	.423	1.000		
P29	.124	.168	.129	.200	.107	.106	.035	.142	.204	-.078	.122	.206	.201	.263	.288	.131	.110	.139	.115	.101	.266	.247	.122	.224	.143	.233	.148	.258	1.000	
P30	.282	.207	.089	.276	.190	.178	.195	.062	.310	.149	.260	.235	.167	.241	.262	.093	.167	.097	.102	.286	.302	.205	.163	.125	.263	.191	.201	.273	.305	1.000

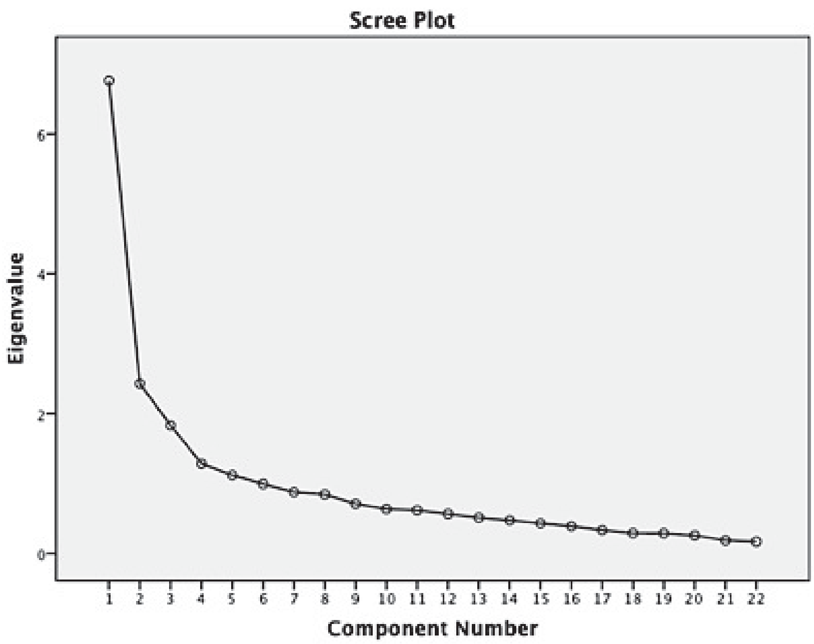
MBI correlation matrix

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22
M1	1.000																					
M2	.712	1.000																				
M3	.690	.749	1.000																			
M4	.148	.235	.186	1.000																		
M5	.166	.260	.201	-.079	1.000																	
M6	.423	.415	.443	-.004	.265	1.000																
M7	.128	.182	.058	.300	-.173	-.042	1.000															
M8	.702	.634	.652	.134	.106	.522	.092	1.000														
M9	-.099	-.091	-.143	-.009	-.074	-.189	.233	-.257	1.000													
M10	.132	.188	.195	-.233	.257	.360	-.149	.292	.024	1.000												
M11	.256	.277	.281	-.155	.149	.426	-.129	.478	-.166	.527	1.000											
M12	-.395	-.273	-.377	-.014	-.095	-.332	.206	-.395	.326	.004	-.120	1.000										
M13	.518	.407	.458	.010	.093	.374	.069	.563	-.099	.157	.320	-.330	1.000									
M14	.493	.495	.479	.128	.088	.404	.106	.594	-.167	.214	.293	-.183	.533	1.000								
M15	.173	.207	.272	-.075	.089	.488	-.148	.304	-.266	.318	.343	-.171	.232	.262	1.000							
M16	.434	.349	.443	.014	.125	.624	-.025	.574	-.204	.313	.382	-.306	.463	.414	.424	1.000						
M17	-.261	-.169	-.205	.167	-.109	-.192	.150	-.239	.112	.027	.053	.314	-.317	-.082	-.150	-.141	1.000					
M18	-.052	-.109	-.035	.151	-.210	-.083	.138	-.057	.225	-.012	.014	.219	-.070	.008	-.155	-.027	.252	1.000				
M19	-.099	-.040	-.025	.105	-.131	-.146	.155	-.221	.429	-.073	-.177	.373	-.259	-.133	-.210	-.232	.279	.441	1.000			
M20	.558	.548	.548	.063	.125	.519	.030	.630	-.186	.274	.456	-.292	.589	.509	.429	.687	-.163	-.117	-.218	1.000		
M21	-.340	-.262	-.354	.088	-.329	-.374	.285	-.277	.240	-.233	-.180	.398	-.140	-.249	-.263	-.400	.195	.222	.265	-.254	1.000	
M22	.225	.270	.289	.074	.153	.268	-.076	.311	.013	.270	.221	-.058	.326	.268	.145	.244	-.114	.076	.020	.351	-.142	1.000

24. PES-NWI principal component analysis scree plot



MBI principle component analysis scree plot



25. Subscale factor loadings

(Page 1 of 2)

Subscale	PES-NWI Indicator Description	Item No.	Factor Loading
Nurse Participation in Hospital Affairs	Career development/clinical ladder opportunity	5	.559
	Opportunity for nurses to participate in policy decisions	6	.654
	A senior nursing administrator who is highly visible and accessible to staff	11	.542
	A senior nursing administrator equal in power and authority to other top level hospital executives	15	.492
	Opportunities for advancement	17	.558
	Administration that listens and responds to employee concerns	21	.481
	Nurses are involved in the internal governance of the hospital (e.g. practice and policy committees)	23	.717
	Nurses have the opportunity to serve on hospital and nursing committees	27	.776
	Nurse managers consult with staff on daily problems and procedures	28	.429
	Active staff development or continuing education programs for nurses	4	.648
Nursing Foundations for Quality Care	High standards of nursing care are expected by the administration	14	.497
	A clear philosophy of nursing that pervades the patient care environment	18	.601
	Working with nurses who are clinically competent	19	.554
	An active quality assurance program	22	.586
	A preceptor program for newly hired nurses	25	.582
	Nursing care is based on a nursing rather than a medical model	26	.522
	Written up-to-date nursing care plans for all patients	29	.510
	Patient care assignments that foster continuity of care (i.e., the same nurse cares for the patient from one day to the next)	30	.633
Nurse Manager Ability, Leadership and Support of Nurses	A supervisory staff that is supportive of the nurses	3	.360
	Supervisors use mistakes as learning opportunities, not criticism	7	.640
	A nurse manager or immediate supervisor who is a good manager and leader	10	.805
	Praise and recognition for a job well done	13	.544
	A nurse manager or supervisor who backs up the nursing staff in decision making, even if the conflict is with a doctor	20	.536
Staffing and Resource Adequacy	Adequate support services allow me to spend time with my patients	1	.522
	Enough time and opportunity to discuss patient care problems with other nurses	8	.575
	Enough registered nurses on staff to provide quality patient care	9	.625
	Enough staff to get the work done	12	.781
Collegial Nurse-Doctor relations	Doctors and nurses have a good working relationship	2	.718
	A lot of team work between nurses and doctors	16	.753
	Collaboration between nurses and doctors	24	.767

Subscale	MBI Indicator Description	Item No.	Factor Loading
Depersonalisation	I feel I treat some recipients as if they were impersonal objects.	5	.331
	I've become more callous toward people since I took this job	10	.780
	I worry that this job is hardening me emotionally	11	.686
	I don't really care what happens to some recipients	15	.526
	I feel recipients blame me for some of their problems	22	.322
Emotional Exhaustion	I feel emotionally drained from my work	1	.822
	I feel used up at the end of the workday	2	.813
	I feel fatigued when I get up in the morning and have to face another day on the job	3	.804
	Working with people all day is really a strain for me	6	.533
	I feel burned out from my work	8	.816
	I feel frustrated by my job	13	.657
	I feel I'm working too hard on my job	14	.686
	Working with people directly puts too much stress on me	16	.576
	I feel like I'm at the end of my rope	20	.718
Personal Accomplishment	I can easily understand how my recipients feel about things	4	.465
	I deal very effectively with the problems of my recipients	7	.410
	I feel I'm positively influencing other people's lives through my work	9	.579
	I feel very energetic	12	.638
	I can easily create a relaxed atmosphere with my recipients	17	.548
	I feel exhilarated after working closely with my recipients	18	.649
	I have accomplished many worthwhile things in this job	19	.713
	In my work, I deal with emotional problems very calmly	21	.483

26. Varimax rotation subscale factor loadings

PES-NWI

	Rotation Sums of Squares Loadings	
Component	% of Variance	Cumulative %
1	14.541	14.54
2	11.933	26.47
3	10.492	36.97
4	10.483	47.45
5	6.248	53.70

MBI

	Rotation Sums of Squares Loadings	
Component	% of Variance	Cumulative %
1	24.976	24.98
2	12.612	37.59
3	12.520	50.11

27. Confirmatory factor analysis

(Page 1 of 2)

PES-NWI[15] [16]

Goodness of Fit Indices	Value
RMSEA	0.08 (90% CI 0.07 - 0.09: p = 0.000)
CD	0.98
CFI	0.80 (0.78)
TLI	0.89

[15] A five-factor CFA analytic model with adequate fit indices provided evidence of factorial validity (internal structure). Validity evidence includes instrument content (expert evaluations), internal structure (e.g., item analysis, factor analysis) and relationships to other variables (e.g., convergent, discriminant, criterion). CFA addresses multiple validations simultaneously (Gajewski et al. 2010). Restrictions can be placed on parameter estimates including factor loadings, variances and covariance's, thereby resulting in a more parsimonious model (Brown 2003). Initially developed by Jöreskog (1967), CFA is used to test whether measures of a construct are consistent the understanding of the nature of that construct or factor. As such, the objective of confirmatory factor analysis is to test whether the data fit a hypothesised measurement model i.e. the PES-NWI in the present study. Statistically significant relationships between the manifest variables (items) and the latent variable (subscale) provide support for convergent validity, whereas low to moderate correlations among the subscales provide evidence of discriminant validity. This provided a measure of fit to the model for the data in this present study. Goodness of fit was evaluated using the Root Mean Square Error of Approximation (RMSEA) and its 90% Confidence Interval (90% CI), Coefficient of Determination (CD), Comparative Fit Index (CFI), and the Tucker–Lewis Index (TLI) (Kline 2011). Acceptable model fit was defined by the criteria: RMSEA (<0.08, 90% CI < 0.08), CD (>0.80), CFI (>0.80) and TLI (>0.90). Multiple indices were used because they provide different information about model fit i.e. absolute fit, fit adjusting for model parsimony, fit relative to a null model, and when used together, these indices provide a more conservative and reliable evaluation of the solution (Brown 2003).

[16] The total nurse sample was used to evaluate whether the PES-NWI measurement properties using STATA 14 (Statacorp, Texas) statistical software due to IBM SPSS 22 being limited to exploratory factor analysis.

MBI[17]

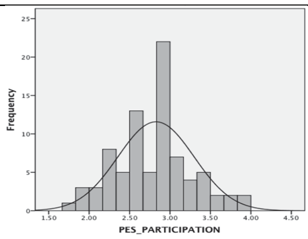
Goodness of Fit Indices	Value
RMSEA	0.05 (90% CI 0.03 - 0.07: $p < 0.05$)
CD	0.99
CFI	0.80 (0.94)
TLI	0.93

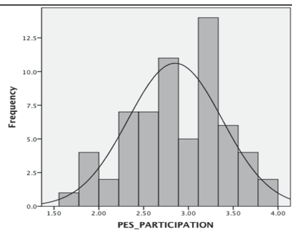
[17] The three-factor MBI CFA analytic model was assessed using STATA 14 statistical software program according to the process and parameters used in the PES-NWI CFA. All goodness of fit indices indicated the three-factor model was an acceptable fit to the data. The twenty-two item MBI used in this study was shown to be a reliable assessment of nurse burnout demonstrating internal consistency with high Cronbach's alpha scores for all subscales. Following PCA using Varimax rotation the twenty-two items loaded onto three factors explaining 50.1% of variance. These findings are consistent with similar studies that considered reliability and validity of MBI as a suitable instrument in acute care nurse populations (Lee, Chien & Yen 2013; Pisanti et al. 2013; Shamali et al. 2015). Furthermore, the reliability and validity attributed to MBI in this nurse sample population emulates the results associated with development of the MBI by the original author (Maslach & Jackson 1981b; Maslach, Jackson & Leiter 1996a).

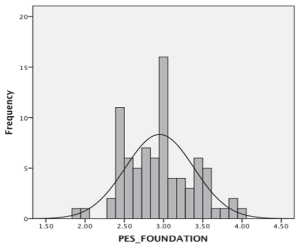
28. Nurse sample distribution plots

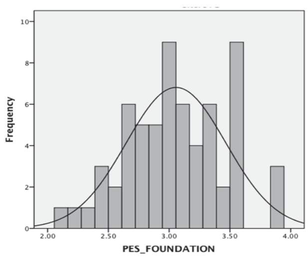
PES-NWI Subscale Histograms [18]

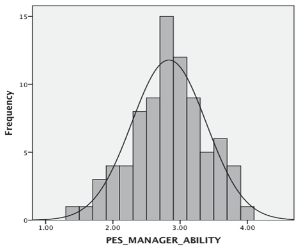
ICUA | **ICUB**

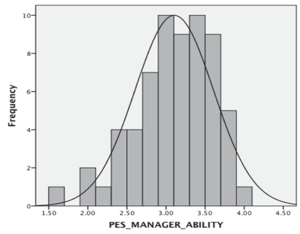


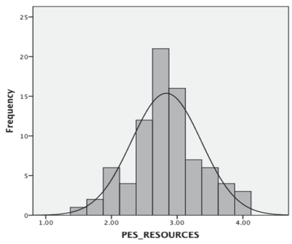


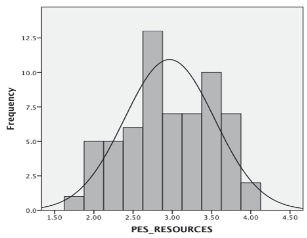


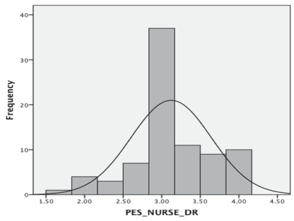


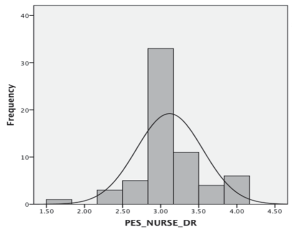








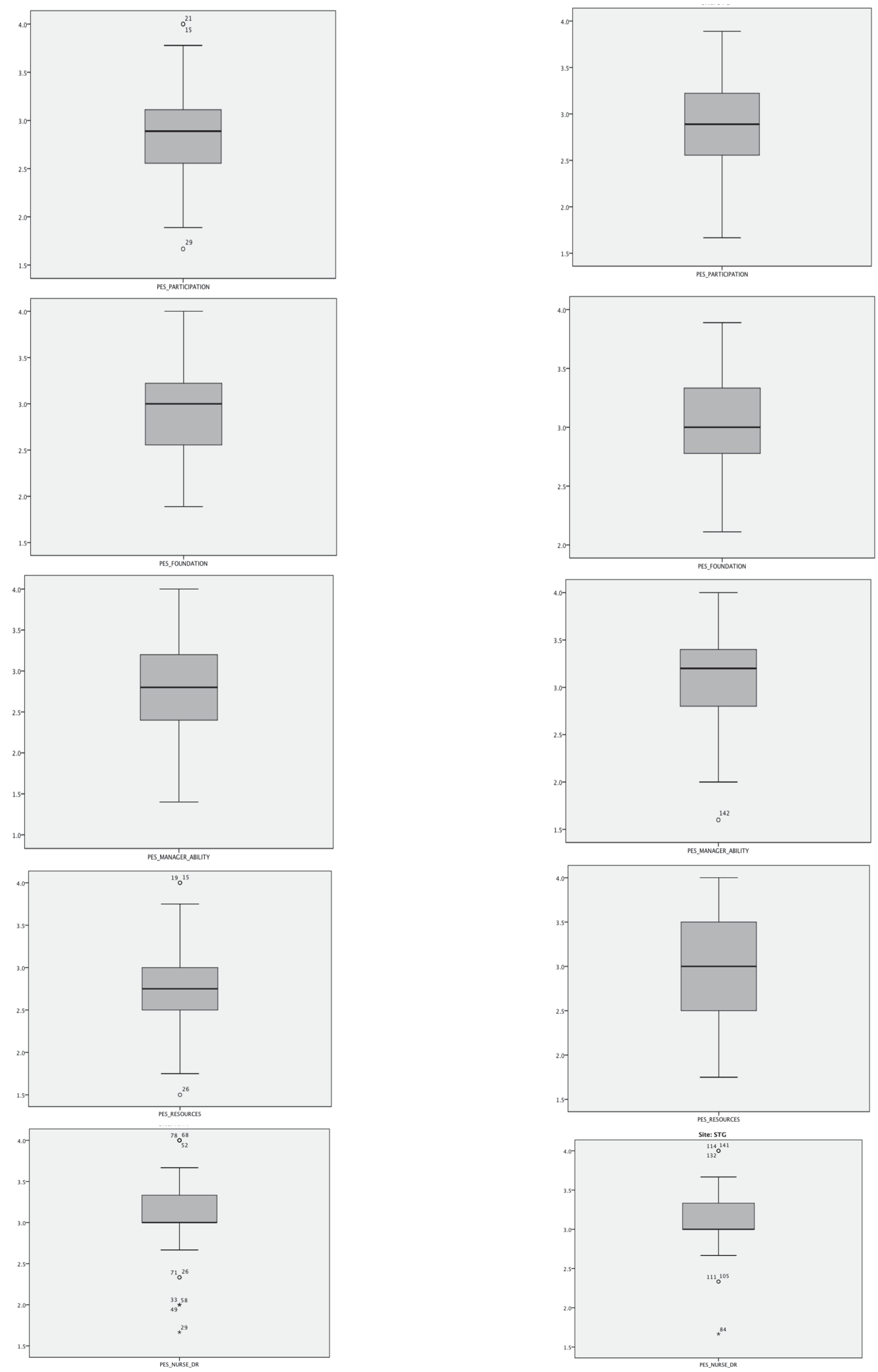




[18] Subscales appeared normally distributed with a slight positive skew displayed for *'Nurse Participation in Hospital Affairs'* and *'Nursing Foundations for Quality of Care'* in the ICUA group. Scores were narrowly dispersed around the mean more than in similar research (Klopper et al. 2012). In particular the *'Nurse Manager Ability, Leadership, and Support of Nurses'* subscale demonstrated a peaked mesokurtic distribution indicating narrow dispersion suggesting a high level of agreement on the performance of the Nurse Manager as a leader in both units.

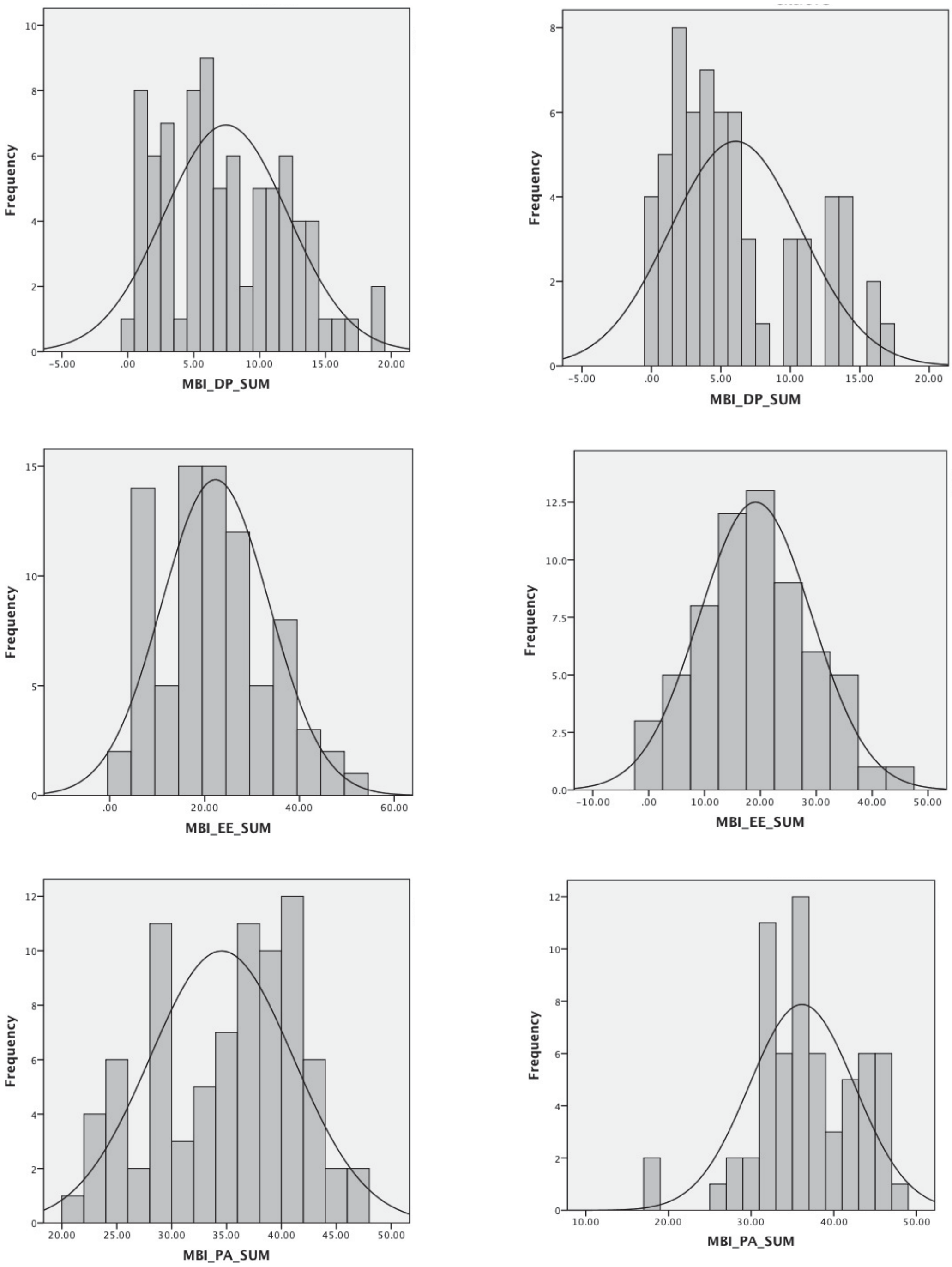
PES-NWI Subscale Boxplots

ICUA | **ICUB**



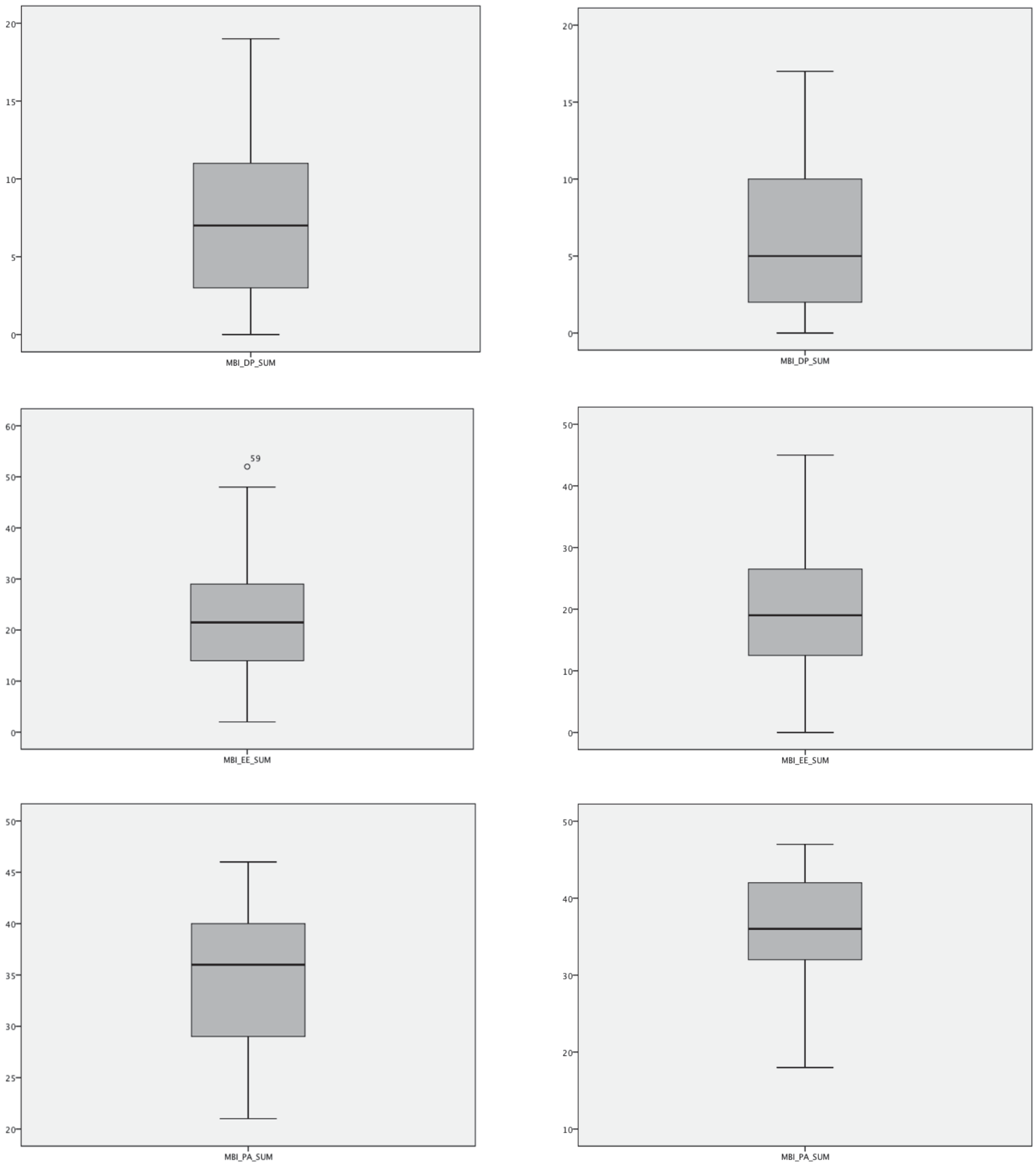
MBI Subscale Histograms

ICUA	ICUB



MBI Subscale Boxplots

ICUA	ICUB



29. Nurse sample distribution test results

(Page 1 of 3)

PES-NWI [1]

Subscale	Statistic	ICUA			ICUB		
Nurse participation in hospital affairs	5%Trimmed Mean	2.82			2.9		
	Skewness [2]	.129	SE .266		-.402	SE .302	
	Kurtosis [2]	.153	SE .526		-.463	SE .595	
		Stat	df	α [3]	Stat	df	α
	Kolmogorov-Smirnov	.089	82	.161	.131	63	.009
	Shapiro-Wilk	.984	82	.422	.969	63	.109
Nursing foundations for quality of care	5%Trimmed Mean	2.9			3.1		
	Skewness	.213	SE .266		-.029	SE .302	
	Kurtosis	-.214	SE .526		-.407	SE .595	
		Stat	df	α	Stat	df	α
	Kolmogorov-Smirnov	.125	82	.003	.079	63	.200
	Shapiro-Wilk	.975	82	.113	.980	63	.392
Nurse Manager ability, leadership and support	5%Trimmed Mean	2.8			3.1		
	Skewness	-.220	SE .266		-.683	SE .302	
	Kurtosis	-.177	SE .526		.330	SE .595	
		Stat	df	α	Stat	df	α
	Kolmogorov-Smirnov	.110	82	.016	.118	63	.029
	Shapiro-Wilk	.980	82	.237	.955	63	.022
Staffing and resource adequacy	5%Trimmed Mean	2.8			3.0		
	Skewness	.036	SE .266		-.132	SE .302	
	Kurtosis	.080	SE .526		-.881	SE .595	
		Stat	df	α	Stat	df	α
	Kolmogorov-Smirnov	.135	82	.001	.126	63	.015
	Shapiro-Wilk	.968	82	.036	.958	63	.031
Collegial Nurse-Physician relations	5%Trimmed Mean	3.1			3.1		
	Skewness	-.234	SE .266		-.015	SE .302	
	Kurtosis	-.353	SE .526		1.65	SE .595	
		Stat	df	α	Stat	df	α
	Kolmogorov-Smirnov	.227	82	.000	.272	63	.000
	Shapiro-Wilk	.905	82	.000	.864	63	.000

Notes:
1. See analysis footnote [13, 14]
2. Zero = perfect symmetry, between - ½ and + ½ = approximate symmetry, between -½ and -1 or +½ and + 1= moderate symmetry, less than – 1 or greater than +1 = a high degree of skewness.
3. α = < 0.05.

PES-NWI subscale calculated z-scores [1]

Subscale		Calculated z-score [2] ICUA	ICUB
Nurse participation in hospital affairs	Skewness	0.48	-1.33
	Kurtosis	0.29	-0.78
Nursing foundations for quality of care	Skewness	0.80	- 0.10
	Kurtosis	- 0.41	- 0.68
Nurse Manager ability, leadership, and support of nurses	Skewness	- 0.82	**- 2.26**
	Kurtosis	- 0.34	0.55
Staffing and resource adequacy	Skewness	0.14	- 0.44
	Kurtosis	0.15	- 1.48
Collegial Nurse- Physician relations	Skewness	- 0.88	- 0.05
	Kurtosis	- 0.67	**2.77**

Notes: 1. See analysis footnote [19,20]
2. Skewness and Kurtosis values divided by the standard error if the ratio (z score) is greater than -1.96 to +1.96 then, in accordance with statistical z-tables, kurtosis is statistically significant at α < 0.05 and the hypothesis of normality is rejected.

[19] 5% trimmed mean values were equal to original mean values for all subscales and the narrow distribution enabled all outliers to be retained. Skewness values reflected approximate symmetry across all subscale scores in ICUA. In contrast moderate to high Kurtosis was found in ICUB for *'*Staffing and resource adequacy' and *'Collegial Nurse- Physician relations'* subscales. Kolmogorov-Smirnov values were statistically significant, indicating the assumption of normality was not upheld for three subscales; *'Nurse Manager ability, leadership, and support of nurses', '*Staffing and resource adequacy' and *'Collegial Nurse-Physician relations'* in both units. Shapiro-Wilk values were statistically significant therefore the assumption of normality was not upheld for '*Nurse Participation in Hospital Affairs'* in ICUB and *'Nursing Foundations for Quality of Care' and 'Nurse Manager Ability, Leadership, and Support of Nurses'* in ICUA. Normal Q-Q plots indicated conformity to a straight line suggesting a close positive correlation between expected and observed normal distributions for each subscale.

[20] Conflicting results required z-scores to be calculated using the standard error to test for distribution symmetry. In a majority of subscales the skewness z statistic indicated approximate symmetry of the distribution for both ICUA and ICUB. The subscale for *'Nurse Manager Ability, Leadership, and Support of Nurses*' subscale was less symmetrical as the z statistic was greater than – 1.96. However, the initial skewness score was – 0.683 and close to approximate symmetry, therefore overall approximate symmetry was assumed for all subscales. Data from ICUB was asymmetrical with a high kurtosis value and the z statistic was > ±1.96 and therefore statistically significant (α = < 0.05). Review of boxplots revealed a single extreme outlier. Taking this into account and the equality between of the sample mean and 5% trimmed means the outlier was retained and the assumption of approximate symmetry upheld.

MBI

Subscale	Statistic	ICUA			ICUB		
Depersonalisation	5%Trimmed Mean	7.25			5.83		
	Skewness [1]	.407	SE .266		**.761**	SE .302	
	Kurtosis[1]	-.**604**	SE .526		**-.562**	SE .595	
		Stat	df	α[2]	Stat	df	α
	Kolmogorov-Smirnov	.109	82	.018	.172	63	.000
	Shapiro-Wilk	.957	82	.007	.901	63	.000
Emotional Exhaustion	5%Trimmed Mean	21.9			19.03		
	Skewness	.388	SE .266		.233	SE .302	
	Kurtosis	-.316	SE .526		-.231	SE .595	
		Stat	df	α	Stat	df	α
	Kolmogorov-Smirnov	.074	82	.200	.069	63	.200
	Shapiro-Wilk	.972	82	.073	.986	63	.676
Personal Accomplishment	5%Trimmed Mean	34.65			36.46		
	Skewness	-.361	SE .266		-.483	SE .302	
	Kurtosis	-.**934**	SE .526		.477	SE .595	
		Stat	df	α	Stat	df	α
	Kolmogorov-Smirnov	.112	82	.013	.107	63	.073
	Shapiro-Wilk	.951	82	.003	.952	63	.015

Notes: 1. zero = perfect symmetry, between - ½ and + ½ = approximate symmetry, between -½ and -1 or +½ and + 1= moderate symmetry, less than – 1 or greater than +1 = a high degree of skewness
2. α = < 0.05.

MBI subscale calculated z-scores

Subscale		Calculated Z Score [1] ICUA	ICUB
Depersonalisation	Skewness	1.53	**2.51**
	Kurtosis	-1.14	-0.94
Emotional Exhaustion	Skewness	1.46	0.77
	Kurtosis	- 0.60	- 0.39
Personal Accomplishment	Skewness	- 1.36	- 1.59
	Kurtosis	- 1.78	0.80

Notes: 1. Skewness and Kurtosis values divided by the standard error, if the ratio (z score) is greater than -1.96 to +1.96 then, in accordance with statistical z-tables, kurtosis is statistically significant at α < 0.05 and the hypothesis of normality is rejected

30. PES-NWI and MBI correlation coefficients

Spearman's rho results for practice environment and burnout subscales

			PES-NWI					MBI		
			PAR	FOU	MAN	RES	COL	DP	EE	PA
	PES_PAR	Corr. Coeff.	1.000							
		Sig. (2-tailed)	.							
	PES_FOU	Corr. Coeff.	.702**	1.000						
		Sig. (2-tailed)	.000	.						
	PES_MAN	Corr. Coeff.	.663**	.526**	1.000					
		Sig. (2-tailed)	.000	.000	.					
	PES_RES	Corr. Coeff.	.453**	.443**	.403**	1.000				
ICUA		Sig. (2-tailed)	.000	.000	.000	.				
N = 82	PES_COL	Corr. Coeff.	.516**	.516**	.447**	.410**	1.000			
		Sig. (2-tailed)	.000	.000	.000	.000	.			
	MBI_DP	Corr. Coeff.	-.234*	-.177	-.118	-.118	-.153	1.000		
		Sig. (2-tailed)	.034	.112	.293	.291	.170	.		
	MBI_EE	Corr. Coeff.	-.564**	-.411**	-.452**	-.443**	-.304**	.438**	1.000	
		Sig. (2-tailed)	.000	.000	.000	.000	.006	.000	.	
	MBI_PA	Corr. Coeff.	.204	.289**	.173	.185	.318**	-.378**	-.321**	1.000
		Sig. (2-tailed)	.066	.008	.121	.096	.004	.000	.003	.
	PES_PAR	Corr. Coeff.	1.000							
		Sig. (2-tailed)	.							
	PES_FOU	Corr. Coeff.	.678**	1.000						
		Sig. (2-tailed)	.000	.						
	PES_MAN	Corr. Coeff.	.747**	.661**	1.000					
		Sig. (2-tailed)	.000	.000	.					
	PES_RES	Corr. Coeff.	.394**	.589**	.384**	1.000				
ICUB		Sig. (2-tailed)	.001	.000	.002	.				
N = 63	PES_COL	Corr. Coeff.	.534**	.494**	.400**	.453**	1.000			
		Sig. (2-tailed)	.000	.000	.001	.000	.			
	MBI_DP	Corr. Coeff.	-.309*	-.214	-.273*	-.303*	-.370**	1.000		
		Sig. (2-tailed)	.014	.091	.031	.016	.003	.		
	MBI_EE	Corr. Coeff.	-.369**	-.177	-.246	-.421**	-.389**	.552**	1.000	
		Sig. (2-tailed)	.003	.165	.052	.001	.002	.000	.	
	MBI_PA	Corr. Coeff.	.285*	.247	.212	.188	.123	-.258*	-.148	1.000
		Sig. (2-tailed)	.023	.051	.096	.140	.337	.041	.248	.

Notes: *Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

31. PES-NWI and MBI subscale correlation coefficients and z-scores[21]

Variable	r	Source	PES_PAR	Z[1]	Two tail p	PES_FOU	Z	Two tail p	PES_MAN	Z	Two tail p	PES_RES	Z	Two tail p	PES_COL	Z	Two tail p	MBI_DP	Z	Two tail p	MBI_EE	Z	Two tail p
PES_PAR	r_1	ICUA	-																				
	r_2	ICUB	-																				
PES_FOU	r_3	ICUA	.702**	.268	.790	-																	
	r_4	ICUB	.678**			-																	
PES_MAN	r_5	ICUA	.663**	-.981	.327	.526**	-1.23	.220	-														
	r_6	ICUB	.747**			.661**			-														
PES_RES	r_7	ICUA	.453**	.420	.674	.443**	-1.17	.242	.403**	.131	.900	-											
	r_8	ICUB	.394**			.589**			.384**			-											
PES_COL	r_9	ICUA	.516**	-.150	.885	.516**	.172	.863	.447**	.340	.740	.410**	-.309	.760	-								
	r_{10}	ICUB	.534**			.494**			.400**			.453**			-								
MBI_DP	r_{11}	ICUA	-.234*	.473	.640	-.177	.230	.822	-.118	.943	.345	-.118	1.13	.257	-.153	1.37	.171	-					
	r_{12}	ICUB	-.309*			-.214			-.273*			-.303*			-.370**			-					
MBI_EE	r_{13}	ICUA	-.564**	-1.47	.142	-.411**	-1.51	.132	-.452**	-1.38	.170	-.443**	-.158	.874	-.304**	.570	.572	.438**	-.890	.380	-		
	r_{14}	ICUB	-.369**			-.177			-.246			-.421**			-.389**			.552**			-		
MBI_PA	r_{15}	ICUA	.204	-.503	.615	.289**	.264	.792	.173	-.237	.813	.185	-.018	.990	.318**	1.20	.230	-.378**	-.781	.435	-.321**	-1.10	.283
	r_{16}	ICUB	.285*			.247			.212			.188			.123			-.258*			-.148		

Notes: 1. Source: http://www.quantpsy.org/corrtest/corrtest.htm (Preacher 2002)

[21] Correlations obtained for the two groups were tested to determine if they were significantly different by converting coefficients into z-scores using Fisher's r-to-z transformation and compared using formula 2.8.5 from Cohen & Cohen (1983, p. 54). By convention, values greater than – 1.96 or + 1.9 are considered significant if a 2-tailed test is performed. No calculated z-obs score breached the -1.96 < z-obs < 1.96 confirming no statistically significant difference exists between groups.

32. Critical Mahalanobis distance values[22]

Number of dependant variables (df.)	Critical Value	PES-NWI ICUA	PES-NWI ICUB	MBI ICUA	MBI ICUB
2	13.82				
3	16.27			10.40	8.87
4	18.47				
5	20.52	15.10	14.51		
6	22.46				
7	24.32				
8	26.13				
9	27.88				
10	29.59				

1. Source: (Pallant 2013) p. 298

[22] Multivariate normality confirmed using linear regression to generate assess Mahalanobis distances to assess multivariate outliers, based on a Chi-square distribution. Critical Chi-square values for two to ten degrees of freedom, at a critical alpha of 0.001, along with corresponding Mahalanobis distances for both subscales are shown above. Results confirmed that no scores exceeded the critical values relevant for the number of dependent variables to be tested using MANOVA. The assumption of multivariate normality was therefore upheld. Additionally, the assumption of linearity was confirmed and dependent variables exhibited moderate correlation.

33. Multivariate MANOVA[1] results

Demographic, work factors and <u>PES-NWI</u> by site (Page 1 of 10)

	PES-NWI Subscale			Box test		Levene's test		Multivariate Wilk's Lambda		Pillai's Trace		Partial Eta Sq.	Univariate Between-Subjects Effects		
			N[a]	F	Sig.[b]	F	Sig.[c]	Value	Sig.[d]	Value	Sig		F	Sig.[e]	Partial Eta Sq.
Gender	PES_PAR	ICUA ICUB	✓ ✓			.802	.495						.059	.809	.000
	PES_FOU	ICUA ICUB	✓ ✓			1.30	.277						.953	.331	.007
	PES_MAN	ICUA ICUB	✓ ✓	1.18	.194	1.20	.317	.976	.640	-	-	.024	.106	.746	.001
	PES_RES	ICUA ICUB	✓ ✓			1.42	.240						.023	.880	.000
	PES_COL	ICUA ICUB	✓ ✓			.797	.497						1.23	.269	.009
Age	PES_PAR	ICUA ICUB	X X			1.68	.066						1.86	.092	.079
	PES_FOU	ICUA ICUB	X X			.625	.840						1.47	.194	.063
	PES_MAN	ICUA ICUB	X X	1.12	.175	1.02	.434	-	-	.165	.846	.033	1.28	.270	.056
	PES_RES	ICUA ICUB	X X			1.86	.036						.610	.722	.027
	PES_COL	ICUA ICUB	X X			1.63	.081						.471	.829	.021
ICU Qualified	PES_PAR	ICUA ICUB	✓ ✓			1.28	.283						.391	.533	.003
	PES_FOU	ICUA ICUB	✓ ✓			.871	.458						.473	.493	.003
	PES_MAN	ICUA ICUB	✓ ✓	1.29	.092	.717	.543	-	-	.028	.556	.028	.312	.577	.002
	PES_RES	ICUA ICUB	✓ ✓			4.51	.005						.565	.453	.004
	PES_COL	ICUA ICUB	✓ ✓			1.73	.322						.257	.613	.002
Highest Nursing Qualification	PES_PAR	ICUA ICUB	✓ ✓			.800	.552						1.19	.306	.017
	PES_FOU	ICUA ICUB	✓ ✓			.982	.431						1.99	.141	.028
	PES_MAN	ICUA ICUB	✓ ✓	1.33	.030	1.57	.173	.947	.678	-	-	.027	2.36	.098	.033
	PES_RES	ICUA ICUB	✓ ✓			1.48	.202						.484	.617	.007
	PES_COL	ICUA ICUB	✓ ✓			.724	.606						.052	.949	.001
Highest Non-Nursing Qualification	PES_PAR	ICUA ICUB	✓ X			.831	.564						1.49	.218	.032
	PES_FOU	ICUA ICUB	✓ X			1.12	.352						2.46	.066	.051
	PES_MAN	ICUA ICUB	✓ X	.835	.776	.507	.828	-	-	.182	.041	.061	1.15	.332	.025
	PES_RES	ICUA ICUB	✓ X			.901	.508						2.27	.083	.047
	PES_COL	ICUA ICUB	✓ X			1.88	.078						2.50	.062	.052

Notes: 1. N in each cell > than number of dependent variables tested = ✓ i.e. PES-NWI = 5
2. Significance > 0.001 the homogeneity of variance is upheld
3. Significance < 0.05 then assumption of equality of variance is violated
4. Significance < 0.5 then a difference between groups
5. Bonferroni correction not applied α = < 0.05

Demographic, work factors and PES-NWI by site (cont'd.)

	PES-NWI Subscale		N[a]	Box test F	Box test Sig.[b]	Levene's test F	Levene's test Sig.[c]	Multivariate Wilk's Lambda Value	Multivariate Wilk's Lambda Sig.[d]	Pillai's Trace Value	Pillai's Trace Sig	Partial Eta Sq.	Univariate Between-Subjects Effects F	Univariate Between-Subjects Effects Sig.[e]	Univariate Between-Subjects Effects Partial Eta Sq.
Job Title	PES_PAR	ICUA ICUB	✓ ✓			.864	.461						.707	.402	.005
	PES_FOU	ICUA ICUB	✓ ✓			1.66	.179						.000	.999	.000
	PES_MAN	ICUA ICUB	✓ ✓	1.08	.330	1.40	.245	.953	.248	-	-	.047	.186	.667	.001
	PES_RES	ICUA ICUB	✓ ✓			2.36	.075						.000	.995	.000
	PES_COL	ICUA ICUB	✓ ✓			1.13	.339						4.78	.031	.033
Years Worked as an RN	PES_PAR	ICUA ICUB	X X			1.44	.149						.470	.829	.021
	PES_FOU	ICUA ICUB	X X			1.04	.422						.931	.475	.041
	PES_MAN	ICUA ICUB	X X	1.22	.065	1.31	.214	-	-	.145	.923	.029	.629	.706	.028
	PES_RES	ICUA ICUB	X X			1.28	.232						.227	.967	.010
	PES_COL	ICUA ICUB	X X			1.16	.314						.843	,539	.037
Years Worked as an RN in ICU	PES_PAR	ICUA ICUB	X ✓			1.07	.391						.801	.551	.029
	PES_FOU	ICUA ICUB	X ✓			.706	.743						1.41	.226	.051
	PES_MAN	ICUA ICUB	X ✓	1.49	.000	2.29	.011	-	-	.202	.321	.040	.705	.620	.026
	PES_RES	ICUA ICUB	X ✓			1.71	.071						2.17	.062	.076
	PES_COL	ICUA ICUB	X ✓			1.74	.070						1.01	.412	.037
Years Worked as an RN in This ICU	PES_PAR	ICUA ICUB	X ✓			2.12	.027						1.34	.258	.038
	PES_FOU	ICUA ICUB	X ✓			1.01	.440						2.25	.067	.063
	PES_MAN	ICUA ICUB	X ✓	1.41	.001	1.99	.039	-	-	.200	.117	.050	1.25	.081	.036
	PES_RES	ICUA ICUB	X ✓			1.48	.155						1.31	.108	.038
	PES_COL	ICUA ICUB	X ✓			1.04	.416						1.65	.066	.047
Employment Status	PES_PAR	ICUA ICUB	✓ ✓			1.05	.372						.795	.374	.006
	PES_FOU	ICUA ICUB	✓ ✓			1.75	.159						.008	.929	.000
	PES_MAN	ICUA ICUB	✓ ✓	1.32	.080	.368	.776	.966	.438	-	-	.034	.288	.592	.002
	PES_RES	ICUA ICUB	✓ ✓			1.20	.311						.155	.695	.001
	PES_COL	ICUA ICUB	✓ ✓			1.77	.155						2.59	.110	.018

Demographic, work factors and PES-NWI by site (cont'd.)

	PES-NWI Subscale			Box test		Levene's test		Multivariate Wilk's Lambda		Pillai's Trace		Partial Eta Sq.	Univariate Between-Subjects Effects		
			N[a]	F	Sig.[b]	F	Sig.[c]	Value	Sig.[d]	Value	Sig		F	Sig.[e]	Partial Eta Sq.
Shift Pattern	PES_PAR	ICUA ICUB	✓ ✓			.857	.465						.275	.099	.019
	PES_FOU	ICUA ICUB	✓ ✓			.777	.509						2.50	.116	.017
	PES_MAN	ICUA ICUB	✓ ✓	1.21	.162	1.68	.174	.936	.104	-	-	.064	1.30	.256	.009
	PES_RES	ICUA ICUB	✓ ✓			2.48	.063						6.09	.015	.041
	PES_COL	ICUA ICUB	✓ ✓			.664	.576						.060	.807	.000
Frequency Redeployed From ICU	PES_PAR	ICUA ICUB	X X			2.31	.019						.481	.750	.014
	PES_FOU	ICUA ICUB	X X			1.97	.058						.535	.711	.016
	PES_MAN	ICUA ICUB	X X	1.28	.043	3.19	.002	-	-	.168	.271	.042	.431	.786	.013
	PES_RES	ICUA ICUB	X X			1.91	.056						.885	.475	.026
	PES_COL	ICUA ICUB	X X			1.16	.324						1.67	.161	.047
Paid Overtime Worked	PES_PAR	ICUA ICUB	✓ X			1.22	.306						.274	.601	.002
	PES_FOU	ICUA ICUB	✓ X			.604	.613						.038	.845	.000
	PES_MAN	ICUA ICUB	✓ X	.805	.765	1.85	.141	-	-	.039	.350	.039	.135	.714	.001
	PES_RES	ICUA ICUB	✓ X			1.27	.288						1.98	.162	.014
	PES_COL	ICUA ICUB	✓ X			.839	.475						.689	.408	.005
Unpaid Overtime Worked	PES_PAR	ICUA ICUB	✓ ✓			1.55	.204						.129	.720	.001
	PES_FOU	ICUA ICUB	✓ ✓			.173	.915						.014	.905	.000
	PES_MAN	ICUA ICUB	✓ ✓	1.32	.074	.494	.687	-	-	.003	.993	.003	.000	.999	.000
	PES_RES	ICUA ICUB	✓ ✓			.951	.418						.067	.796	.000
	PES_COL	ICUA ICUB	✓ ✓			3.31	.022						.005	.947	.000
Roster Flexibility	PES_PAR	ICUA ICUB	✓ X			.751	.629						2.43	.068	.050
	PES_FOU	ICUA ICUB	✓ X			1.52	.166						1.70	.170	.036
	PES_MAN	ICUA ICUB	✓ X	1.21	.106	1.41	.207	-	-	.085	.692	.028	.407	.407	.021
	PES_RES	ICUA ICUB	✓ X			.568	.781						.652	.652	.012
	PES_COL	ICUA ICUB	✓ X			1.37	.224						.497	.497	.017

Demographic, work factors and PES-NWI by site (cont'd.)

	PES-NWI Subscale			Box test		Levene's test		Multivariate Wilk's Lambda		Pillai's Trace		Partial Eta Sq.	Univariate Between-Subjects Effects		
			N[a]	F	Sig.[b]	F	Sig.[c]	Value	Sig.[d]	Value	Sig		F	Sig.[e]	Partial Eta Sq.
CNE Access	PES_PAR	ICUA ICUB	✓ ✓			.224	.952						1.39	.252	.020
	PES_FOU	ICUA ICUB	✓ ✓			1.42	.220						.019	.981	.000
	PES_MAN	ICUA ICUB	✓ ✓	1.05	.358	2.70	.023	-	-	.044	.802	.022	.280	.756	.004
	PES_RES	ICUA ICUB	✓ ✓			1.10	.361						.262	.770	.004
	PES_COL	ICUA ICUB	✓ ✓			1.18	.324						.002	.998	.000
Level of Supervision	PES_PAR	ICUA ICUB	✓ ✓			.608	.694						.549	.579	.008
	PES_FOU	ICUA ICUB	✓ ✓			2.19	.058						.161	.851	.002
	PES_MAN	ICUA ICUB	✓ ✓	1.11	.237	.997	.422	.934	.505	-	-	.033	.031	.969	.000
	PES_RES	ICUA ICUB	✓ ✓			.984	.430						.921	.401	.013
	PES_COL	ICUA ICUB	✓ ✓			2.08	.072						1.03	.359	.015
Required to Mentor Nurses	PES_PAR	ICUA ICUB	✓ ✓			2.47	.016						.143	.934	.003
	PES_FOU	ICUA ICUB	✓ ✓			1.19	.308						.534	.660	.012
	PES_MAN	ICUA ICUB	✓ ✓	.857	.850	1.49	.168	-	-	.049	.446	.016	.077	.973	.002
	PES_RES	ICUA ICUB	✓ ✓			1.43	.190						.243	.867	.005
	PES_COL	ICUA ICUB	✓ ✓			1.008	.433						.367	.777	.008
Required to Provide Clinical Advice	PES_PAR	ICUA ICUB	✓ X			1.08	.380						2.16	.077	.060
	PES_FOU	ICUA ICUB	✓ X			1.56	.135						1.84	.124	.052
	PES_MAN	ICUA ICUB	✓ X	1.18	.117	.791	.625	-	-	.211	.079	.053	1.35	.256	.038
	PES_RES	ICUA ICUB	✓ X			.786	.630						2.30	.062	.064
	PES_COL	ICUA ICUB	✓ X			1.56	.133						3.01	.020	.082
Quality of Care in Past Year	PES_PAR	ICUA ICUB	✓ ✓			1.10	.366						4.35	.006	.087
	PES_FOU	ICUA ICUB	✓ ✓			2.56	.016						1.68	.173	.036
	PES_MAN	ICUA ICUB	✓ ✓	1.03	.417	1.87	.079	-	-	.188	.032	.063	2.14	.078	.048
	PES_RES	ICUA ICUB	✓ ✓			1.08	.379						2.57	.057	.053
	PES_COL	ICUA ICUB	✓ ✓			3.12	.004						.557	.645	.012

Demographic, work factors and PES-NWI by site (cont'd.)

	PES-NWI Subscale			Box test		Levene's test		Multivariate Wilk's Lambda		Pillai's Trace		Partial Eta Sq.	Univariate Between-Subjects Effects		
			N[a]	F	Sig.[b]	F	Sig.[c]	Value	Sig.[d]	Value	Sig		F	Sig.[e]	Partial Eta Sq.
	PES_PAR	ICUA ICUB	X X			2.72	.023						.154	.857	.002
	PES_FOU	ICUA ICUB	X X			4.10	.002						.421	.657	.006
Quality of Care Last Shift	PES_MAN	ICUA ICUB	X X	1.22	.151	1.56	.176	-	-	.039	.863	.019	.378	.686	.005
	PES_RES	ICUA ICUB	X X			2.04	.077						.134	.875	.002
	PES_COL	ICUA ICUB	X X			1.46	.205						.245	.783	.004
	PES_PAR	ICUA ICUB	X ✓			.772	.593						3.87	.023	.053
	PES_FOU	ICUA ICUB	X ✓			2.72	.016						.827	.440	.012
OHS	PES_MAN	ICUA ICUB	X ✓	.934	.638	2.07	.061	-	-	.098	.187	.049	3.18	.045	.044
	PES_RES	ICUA ICUB	X ✓			2.42	.029						1.18	.310	.017
	PES_COL	ICUA ICUB	X ✓			.983	.439						1.25	.291	.018
	PES_PAR	ICUA ICUB	✓ ✓			1.77	.097						.188	.904	.004
	PES_FOU	ICUA ICUB	✓ ✓			1.01	.430						1.02	.387	.022
Social Cohesion	PES_MAN	ICUA ICUB	✓ ✓	1.20	.114	.866	.535	-	-	.170	.064	.057	1.01	.391	.022
	PES_RES	ICUA ICUB	✓ ✓			1.14	.344						1.82	.146	.038
	PES_COL	ICUA ICUB	✓ ✓			2.34	.027						2.05	.110	.043
	PES_PAR	ICUA ICUB	✓ ✓			1.17	.325						.968	.327	.007
	PES_FOU	ICUA ICUB	✓ ✓			.034	.992						1.31	.255	.009
Resign < 12 Months	PES_MAN	ICUA ICUB	✓ ✓	1.43	.031	.733	.534	.942	.143	-	-	.058	4.30	.040	.030
	PES_RES	ICUA ICUB	✓ ✓			1.30	.276						.029	.864	.000
	PES_COL	ICUA ICUB	✓ ✓			.873	.457						.237	.627	.002
	PES_PAR	ICUA ICUB	✓ ✓			2.39	.071						.020	.889	.000
	PES_FOU	ICUA ICUB	✓ ✓			.264	.851						.068	.795	.000
Intend to Move ICUs	PES_MAN	ICUA ICUB	✓ ✓	1.18	.233	2.35	.075	.965	.431	-	-	.035	.072	.788	.001
	PES_RES	ICUA ICUB	✓ ✓			1.29	.282						1.801	.182	.013
	PES_COL	ICUA ICUB	✓ ✓			1.96	.123						.971	.326	.007

Demographic, work factors and PES-NWI by site (cont'd.)

PES-NWI Subscale				Box test		Levene's test		Multivariate Wilk's Lambda		Pillai's Trace		Partial Eta Sq.	Univariate Between-Subjects Effects		
			N[a]	F	Sig.[b]	F	Sig.[c]	Value	Sig.[d]	Value	Sig		F	Sig.[e]	Partial Eta Sq.
Job Satisfaction	PES_PAR	ICUA ICUB	X ✓	.910	.695	3.73	.002	-	-	.072	.435	.036	.371	.691	.005
	PES_FOU	ICUA ICUB	X ✓			1.49	.185						.171	.843	.002
	PES_MAN	ICUA ICUB	X ✓			1.66	.135						1.03	.359	.015
	PES_RES	ICUA ICUB	X ✓			726	.630						.178	.837	.003
	PES_COL	ICUA ICUB	X ✓			2.22	.045						1.01	.368	.014
Satisfaction with Nursing	PES_PAR	ICUA ICUB	X X	.645	.969	.816	.559	-	-	.144	.025	.072	4.26	.016	.058
	PES_FOU	ICUA ICUB	X X			.855	.530						.778	.461	.011
	PES_MAN	ICUA ICUB	X X			1.19	.313						2.38	.096	.033
	PES_RES	ICUA ICUB	X X			.798	.573						1.02	.365	.015
	PES_COL	ICUA ICUB	X X			3.12	.007						0.51	.950	.001

Demographic, work factors and MBI by site

	MBI Subscale		N[a]	Box test F	Box test Sig.[b]	Levene's test F	Levene's test Sig.[c]	Multivariate Wilk's Lambda Value	Multivariate Wilk's Lambda Sig.[d]	Multivariate Pillai's Trace Value	Multivariate Pillai's Trace Sig	Partial Eta Sq	Univariate Between-Subjects Effects F	Univariate Between-Subjects Effects Sig.[e]	Univariate Between-Subjects Effects Partial Eta Sq.
Gender	MBI_DP	ICUA ICUB	✓ ✓			.435	.729						.042	.838	.000
	MBI_EE	ICUA ICUB	✓ ✓	1.03	.426	1.74	.161	.992	.774	-	-	.008	.490	.485	.003
	MBI_PA	ICUA ICUB	✓ ✓			2.27	.083						.106	.745	.001
Age	MBI_DP	ICUA ICUB	X X			1.92	.030						1.11	.363	.049
	MBI_EE	ICUA ICUB	X X	1.10	.277	2.67	.002	-	-	.177	.148	.059	1.91	.085	.081
	MBI_PA	ICUA ICUB	X X			1.42	.152						1.10	.366	.048
ICU Qualified	MBI_DP	ICUA ICUB	✓ ✓			.091	.965						2.04	.155	.014
	MBI_EE	ICUA ICUB	✓ ✓	.962	.502	1.03	.381	.976	.345	-	-	.024	1.11	.293	.008
	MBI_PA	ICUA ICUB	✓ ✓			1.93	.128						.362	.548	.003
Highest Nursing Qualification	MBI_DP	ICUA ICUB	✓ ✓			.511	.768						1.44	.241	.020
	MBI_EE	ICUA ICUB	✓ ✓	.873	.665	1.08	.374	.964	.541	-	-	.018	.187	.830	.003
	MBI_PA	ICUA ICUB	✓ ✓			.705	.621						.709	.494	.010
Highest Non-Nursing Qualification	MBI_DP	ICUA ICUB	✓ ✓			1.29	.258						1.33	.267	.028
	MBI_EE	ICUA ICUB	✓ ✓	1.30	.113	1.26	.274	.889	.066	-	-	.038	3.08	.030	.063
	MBI_PA	ICUA ICUB	✓ ✓			1.63	.132						1.04	.377	.022
Job Title	MBI_DP	ICUA ICUB	✓ ✓			.578	.630						.415	.521	.003
	MBI_EE	ICUA ICUB	✓ ✓	1.33	.155	.690	.559	.979	.406	-	-	.021	.064	.800	.000
	MBI_PA	ICUA ICUB	✓ ✓			2.52	.061						1.65	.202	.012
Years Worked as an RN	MBI_DP	ICUA ICUB	X ✓			1.75	.059						.502	.806	.022
	MBI_EE	ICUA ICUB	X ✓	1.47	.008	3.26	.000	-	-	.077	.916	0.26	.175	.983	.008
	MBI_PA	ICUA ICUB	X ✓			1.92	.033						1.13	.346	.049
Years Worked as an RN in ICU	MBI_DP	ICUA ICUB	X ✓			1.70	.073						2.11	.060	.074
	MBI_EE	ICUA ICUB	X ✓	1.31	.051	2.90	.001	-	-	.145	.173	.048	1.62	.158	.058
	MBI_PA	ICUA ICUB	X ✓			3.01	.001						.697	.627	.026

Notes: 1. N in each cell > than number of dependent variables tested = ✓ i.e. MBI = 3
2. Significance > 0.001 the homogeneity of variance is upheld
3. Significance < 0.05 then assumption of equality of variance is violated
4. Significance < 0.5 then a difference between groups
5. Bonferroni correction not applied α = < 0.05

Demographic, work factors and MBI by site (cont'd.)

	MBI Subscale			Box test		Levene's test		Multivariate Wilk's Lambda		Pillai's Trace		Partial Eta Sq.	Univariate Between-Subjects Effects		
			N[a]	F	Sig.[b]	F	Sig.[c]	Value	Sig.[d]	Value	Sig		F	Sig.[e]	Partial Eta Sq.
Years Worked as an RN in THIS ICU	MBI_DP	ICUA / ICUB	X / ✓			.384	.952						1.32	.265	.038
	MBI_EE	ICUA / ICUB	X / ✓	.966	.546	1.00	.445	-	-	.092	.394	.031	.806	.524	.023
	MBI_PA	ICUA / ICUB	X / ✓			2.67	.005						1.60	.178	.046
Employment Status	MBI_DP	ICUA / ICUB	✓ / ✓			4.04	.009						1.81	.180	.013
	MBI_EE	ICUA / ICUB	✓ / ✓	.892	.589	.692	.559	-	-	.016	.531	.016	.412	.522	.003
	MBI_PA	ICUA / ICUB	✓ / ✓			.526	.665						.071	.790	.001
Shift Pattern	MBI_DP	ICUA / ICUB	✓ / ✓			1.04	.379						.772	.381	.005
	MBI_EE	ICUA / ICUB	✓ / ✓	.903	.575	.962	.412	.994	.851	-	-	.006	.112	.738	.001
	MBI_PA	ICUA / ICUB	✓ / ✓			1.16	.328						.013	.908	.000
Frequency Deployed from ICU	MBI_DP	ICUA / ICUB	X / X			2.51	.011						.927	.395	.030
	MBI_EE	ICUA / ICUB	X / X	.954	.556	.952	.483	-	-	.052	.844	.017	.228	.961	.005
	MBI_PA	ICUA / ICUB	X / X			1.29	.246						.333	.735	.015
Paid Overtime Worked	MBI_DP	ICUA / ICUB	✓ / X			1.19	.316						.000	.997	.000
	MBI_EE	ICUA / ICUB	✓ / X	1.11	.348	1.55	.204	-	-	.002	.974	.002	.079	.779	.001
	MBI_PA	ICUA / ICUB	✓ / X			.936	.425						.076	.783	.001
Unpaid Overtime Worked	MBI_DP	ICUA / ICUB	✓ / ✓			.334	.801						2.51	.116	.017
	MBI_EE	ICUA / ICUB	✓ / ✓	1.14	.305	.884	.451	.977	.358	-	-	.023	.105	.746	.001
	MBI_PA	ICUA / ICUB	✓ / ✓			.434	.729						.053	.819	.000
Roster Flexibility	MBI_DP	ICUA / ICUB	✓ / ✓			1.49	.175						.246	.864	.005
	MBI_EE	ICUA / ICUB	✓ / ✓	1.20	.180	1.44	.195	.952	.673	-	-	.016	.419	.740	.009
	MBI_PA	ICUA / ICUB	✓ / ✓			1.84	.084						1.33	.266	.028
CNE Access	MBI_DP	ICUA / ICUB	✓ / ✓			1.74	.129						1.76	.177	.025
	MBI_EE	ICUA / ICUB	✓ / ✓	1.41	.069	1.37	.240	-	-	.052	.287	.026	.147	.863	.002
	MBI_PA	ICUA / ICUB	✓ / ✓			2.87	.017						1.63	.199	.023
Level of Supervision	MBI_DP	ICUA / ICUB	✓ / ✓			.759	.581						2.66	.074	.037
	MBI_EE	ICUA / ICUB	✓ / ✓	.982	.494	.430	.827	.875	.005	-	-	.065	1.47	.234	.021
	MBI_PA	ICUA / ICUB	✓ / ✓			.908	.478						4.03	.020	.055

Demographic, work factors and MBI by site (cont'd.)

	MBI Subscale		Box test		Levene's test		Wilk's Lambda		Pillai's Trace		Partial Eta Sq.	Between-Subjects Effects		
		N[a]	F	Sig.[b]	F	Sig.[c]	Value	Sig.[d]	Value	Sig		F	Sig.[e]	Partial Eta Sq.
Required to Mentor	MBI_DP	ICUA ✓ ICUB ✓			1.19	.312						.711	.547	0.015
	MBI_EE	ICUA ✓ ICUB ✓	.786	.855	.465	.879	.969	.891	-	-	.010	.080	.971	.002
	MBI_PA	ICUA ✓ ICUB ✓			.387	.926						.174	.914	.004
Required to Provide Clinical Advice	MBI_DP	ICUA ✓ ICUB ✓			1.17	.317						.812	.520	.023
	MBI_EE	ICUA ✓ ICUB ✓	.964	.543	.867	.556	.912	.408	-	-	.030	1.12	.350	.032
	MBI_PA	ICUA ✓ ICUB ✓			.609	.788						.998	.411	.029
Quality of Care in Past Year	MBI_DP	ICUA ✓ ICUB ✓			.714	.661						.182	.908	.004
	MBI_EE	ICUA ✓ ICUB ✓	.927	.606	.934	.482	.950	.631	`-	-	.017	.544	.653	.012
	MBI_PA	ICUA ✓ ICUB ✓			1.31	.252						1.03	.383	.022
Quality of Care Last Shift	MBI_DP	ICUA X ICUB X			1.75	.128						.567	.568	.008
	MBI_EE	ICUA X ICUB X	1.25	.208	.759	.581	-	-	.041	.451	.020	.212	.809	.003
	MBI_PA	ICUA X ICUB X			2.06	.027						1.15	.318	.016
OHS	MBI_DP	ICUA X ICUB ✓			3.42	.004						2.99	.054	.041
	MBI_EE	ICUA X ICUB ✓	1.37	.086	1.70	.124	-	-	.095	.037	.047	2.43	.092	.034
	MBI_PA	ICUA X ICUB ✓			1.11	.361						.826	.440	.012
Social Cohesion	MBI_DP	ICUA ✓ ICUB ✓			2.12	.045						.805	.493	.017
	MBI_EE	ICUA ✓ ICUB ✓	.727	.885	.679	.690	-	-	.041	.769	.014	.553	.647	.012
	MBI_PA	ICUA ✓ ICUB ✓			1.15	.337						.221	.881	.005
Resign < 12 months	MBI_DP	ICUA ✓ ICUB ✓			2.70	.048						5.85	.017	.040
	MBI_EE	ICUA ✓ ICUB ✓	1.07	.377	1.31	.272	-	-	.055	.047	.055	2.14	.146	.015
	MBI_PA	ICUA ✓ ICUB ✓			.810	.490						.476	.491	.003
Intend to Move ICUs	MBI_DP	ICUA ✓ ICUB ✓			.127	.944						.265	.608	.002
	MBI_EE	ICUA ✓ ICUB ✓	.714	.800	.708	.549	.956	.098	-	-	.044	1.79	.183	.013
	MBI_PA	ICUA ✓ ICUB ✓			.465	.707						2.90	.091	.020
Job Satisfaction	MBI_DP	ICUA ✓ ICUB ✓			.601	7.29						1.49	.229	.021
	MBI_EE	ICUA ✓ ICUB ✓	1.14	.250	1.53	.172	.947	.278	-	-	.027	.292	.747	.004
	MBI_PA	ICUA ✓ ICUB ✓			1.40	.220						1.35	.263	.019
Satisfaction with Nursing	MBI_DP	ICUA X ICUB ✓			1.68	.131						1.50	.227	.021
	MBI_EE	ICUA X ICUB ✓	1.09	.351	1.40	.218	-	-	.051	.306	.026	.305	.737	.004
	MBI_PA	ICUA X ICUB ✓			.462	.836						.312	.732	.005

MANOVA Note (1):

- In total, PES-NWI and MBI subscales were tested against 27 demographic characteristics and work factors. In all tests on both scales Box's M Test of Equality of Covariance Matrices was not significant thereby upholding the assumption of homogeneity of variance. The assumption regarding an adequate cell size (N) and Levene's Test of Equality of Error Variances were violated by several tests resulting in Pillai's Trace statistic being used to assess significance of the multivariate test. Wilk's Lamba was not significant in any test performed.
- MANOVA compares the groups and identifies if there is a significant difference on the composite dependent variable and on each separate dependent variable (Pallant 2013). Extensive factor analysis has established that PES-NWI and MBI subscales are conceptually related, satisfying a key requirement for MANOVA. An advantage of this analysis, compared to a series of one-way and two-way ANOVA's, is that it reduces the risk of a Type I error i.e. finding a significant statistical difference when in reality no difference exists, through adjustment based upon the number of analysis undertaken. Furthermore, MANOVA can be used in two-way factorial designs with multiple independent variables in higher factorial designs such as the present study.
- Appropriate sample size for MANOVA was confirmed with each cell having more cases than the number of dependent variables being explored. Subscale distributions confirmed univariate normality and no presence of significant outliers.
- The MANOVA included Box's M Test of Equality of Covariance Matrices and Levene's Test of Equality of Error Variances to validate the assumptions of equality of variance for the dependent variable. Multivariate tests of significance were reported using Wilks' Lambda value and its associated significance level, recommended for general use, whereby a significance level less than 0.05 indicates a difference between groups (Tabachnick & Fidell 2013). Where issues with the data were encountered such as inadequate N values or violation of assumptions then Pillai's Trace value was used as it is considered more robust (Tabachnick & Fidell 2013).
- The large number of separate analysis performed on the datasets increased the potential for a Type 1 error. To reduce the risk the alpha level for multiple tests may be adjusted to make it smaller by performing a Bonferroni correction for each p-value to adjust the alpha level by dividing by the number of comparisons made to reduce the chance of a Type 1 error. In the case of PES-NWI the new level of significance would have been alpha 0.01 and for MBI the revised alpha was 0.17 (Pallant 2013). On further investigation of this statistical technique it was evident from the literature that applying the Bonferroni correction is controversial due to reducing statistical power and increasing the chance of a Type II error (Armstrong 2014; Perneger 1998). Taking this into account and the close demographic and work factor similarities between the two nurse groups, Bonferroni correction was not applied and statistical significance of 0.05 was retained.

34. Two-way ANOVA PES-NWI and MBI

(Page 1 of 8)

Note: Factorial two-way independent ANOVA with Tukey's *post hoc* tests were performed on; 1) MBI_PA by Site*Supervision; 2) PES_PARTICIPATION by Site*Quality of Care; 3) MBI_DP by Site*OHS; and 4) PES_PARTICIPATION by Site*Nursing Satisfaction. Post hoc analyses strengthened induction by limiting the probability that significant effects may be observed when it is in fact a Type I error (Tabachnick & Fidell 2013).

MBI_PA BY Site* Supervision

Descriptive Statistics (Dependent Variable: MBI_PA)

Site	Supervision	Mean	Std. Deviation	N
1.00 ICUA	2.00 Fair	4.2266	.89001	16
	3.00 Good	4.2847	.78511	54
	4.00 Excellent	4.5937	.88408	12
	Total	4.3186	.81842	82
2.00 ICUB	2.00 Fair	3.3958	.89239	6
	3.00 Good	4.5369	.70535	44
	4.00 Excellent	4.9712	.56170	13
	Total	4.5179	.79719	63
Total	2.00 Fair	4.0000	.94806	22
	3.00 Good	4.3980	.75713	98
	4.00 Excellent	4.7900	.74365	25
	Total	4.4052	.81254	145

Levene's Test of Equality of Error Variances [1] (Dependent Variable: MBI_PA)

F	df_1	df_2	Sig.
.908	5	139	.478

1. Design: Intercept + Site + Supervision + Site * Supervision

Tests of Between-Subjects Effects (Dependent Variable: MBI_PA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12.761[1]	5	2.552	4.310	.001	.134
Intercept	1570.733	1	1570.733	2652.565	.000	.950
Site	.094	1	.094	.159	.691	.001
Supervision	9.713	2	4.856	8.201	.000	.106
Site * Supervision	4.769	2	2.384	4.027	.020	.055
Error	82.310	139	.592			
Total	2908.875	145				
Corrected Total	95.071	144				

1. R Squared = .134 (Adjusted R Squared = .103)

Tukey HSD *Post Hoc* Tests: Supervision (Dependent Variable: MBI_PA)

(I) Supervision	(J) Supervision	Mean[1] Difference (I-J)	Std. Error[2]	Sig.	95% Confidence Interval Lower Bound	Upper Bound
2.00 Fair	3.00 Good	-.3980	.18155	.076	-.8281	.0321
	4.00 Excellent	-.7900*	.22495	.002	-1.3229	-.2571
3.00 Good	2.00 Fair	.3980	.18155	.076	-.0321	.8281
	4.00 Excellent	-.3920	.17242	.063	-.8005	.0164
4.00 Excellent	2.00 Fair	.7900*	.22495	.002	.2571	1.3229
	3.00 Good	.3920	.17242	.063	-.0164	.8005

1. Based on observed means.
2. The error term is Mean Square (Error) = .592.

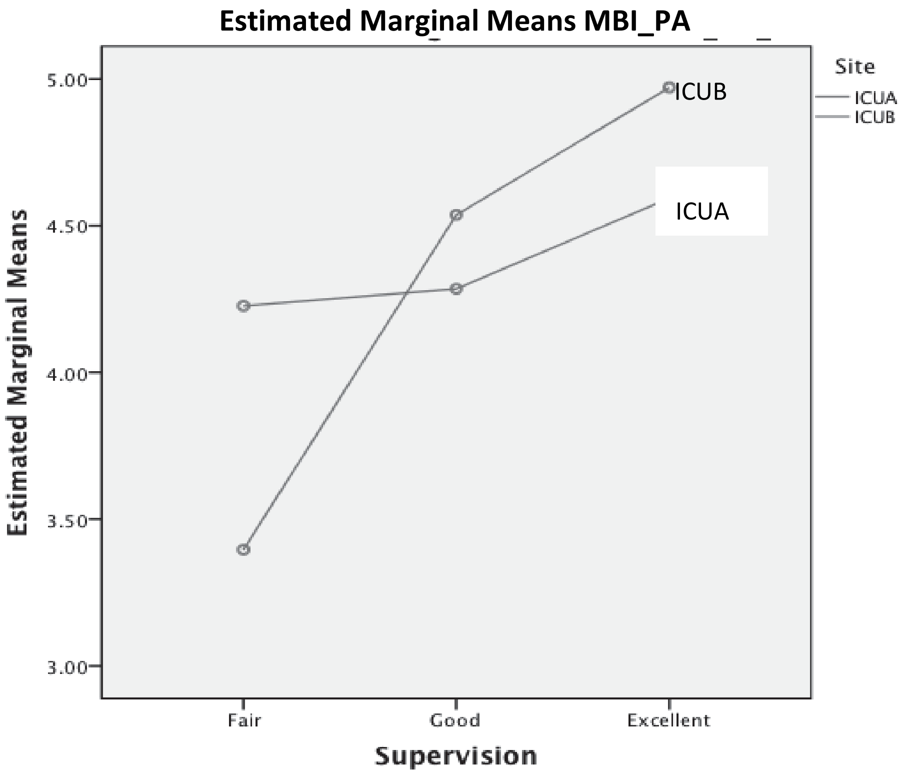
Homogeneous Subsets (MBI_PA)

Tukey HSD[1,2,3]

Supervision	N	Subset 1	2
2.00 Fair	22	4.0000	
3.00 Good	98	4.3980	4.3980
4.00 Excellent	25		4.7900
Sig.		.105	.112

1. Uses Harmonic Mean Sample Size = 31.362
2. The group sizes are unequal. The harmonic mean of the group sizes is used.
3. Type I error levels are not guaranteed.

Profile Plots



PES_PARTICIPATION BY Site* Quality of Care

Descriptive Statistics (Dependent Variable: PES_PARTICIPATION)

Site	Quality of Care	Mean	Std. Deviation	N
1.00 ICUA	1.00 Worked < 1 yr	3.1944	.44223	12
	2.00 Deteriorated	2.5556	.28974	11
	3.00 Remained the same	2.7456	.42204	38
	4.00 Improved	2.9054	.52766	21
	Total	2.8267	.47090	82
2.00 ICUB	1.00 Worked < 1 yr	3.0694	.31392	8
	2.00 Deteriorated	1.8667	.16480	5
	3.00 Remained the same	2.7302	.39710	28
	4.00 Improved	3.1515	.46201	22
	Total	2.8519	.52610	63
Total	1.00 Worked < 1 yr	3.1444	.39176	20
	2.00 Deteriorated	2.3403	.41469	16
	3.00 Remained the same	2.7391	.40859	66
	4.00 Improved	3.0313	.50478	43
	Total	2.8376	.49402	145

Levene's Test of Equality of Error Variances [1] (Dependent Variable: PES_PARTICIPATION)

F	df1	df2	Sig.
1.101	7	137	.366

1. Design: Intercept + Site + Quality_Care + Site * Quality_Care

Tests of Between-Subjects Effects (Dependent Variable: PES_PARTICIPATION)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10.456[1]	7	1.494	8.289	.000	.298
Intercept	754.457	1	754.457	4186.651	.000	.968
Site	.520	1	.520	2.885	.092	.021
Quality_Care	9.257	3	3.086	17.123	.000	.273
Site * Quality_Care	2.352	3	.784	4.350	.006	.087
Error	24.688	137	.180			
Total	1202.716	145				
Corrected Total	35.144	144				

1. R Squared = .298 (Adjusted R Squared = .262)

Tukey HSD Post Hoc Tests (Dependent Variable: PES_PARTICIPATION)

(I) Quality_Care	(J) Quality_Care	Mean [1] Difference (I-J)	Std. Error[2]	Sig.	95% Confidence Interval Lower	Upper
1.00 Worked < 1 yr	2.00 Deteriorated	.8042*	.14238	.000	.4338	1.1745
	3.00 Remained the same	.4054*	.10835	.002	.1236	.6872
	4.00 Improved	.1131	.11490	.759	-.1857	.4119
2.00 Deteriorated	1.00 Worked < 1 yr	-.8042*	.14238	.000	-1.1745	-.4338
	3.00 Remained the same	-.3988*	.11829	.005	-.7064	-.0911
	4.00 Improved	-.6911*	.12431	.000	-1.0144	-.3677
3.00 Remained the same	1.00 Worked < 1 yr	-.4054*	.10835	.002	-.6872	-.1236
	2.00 Deteriorated	.3988*	.11829	.005	.0911	.7064
	4.00 Improved	-.2923*	.08319	.003	-.5086	-.0759
4.00 Improved	1.00 Worked < 1 yr	-.1131	.11490	.759	-.4119	.1857
	2.00 Deteriorated	.6911*	.12431	.000	.3677	1.0144
	3.00 Remained the same	.2923*	.08319	.003	.0759	.5086

1. Based on observed means.
2. The error term is Mean Square (Error) = .180.

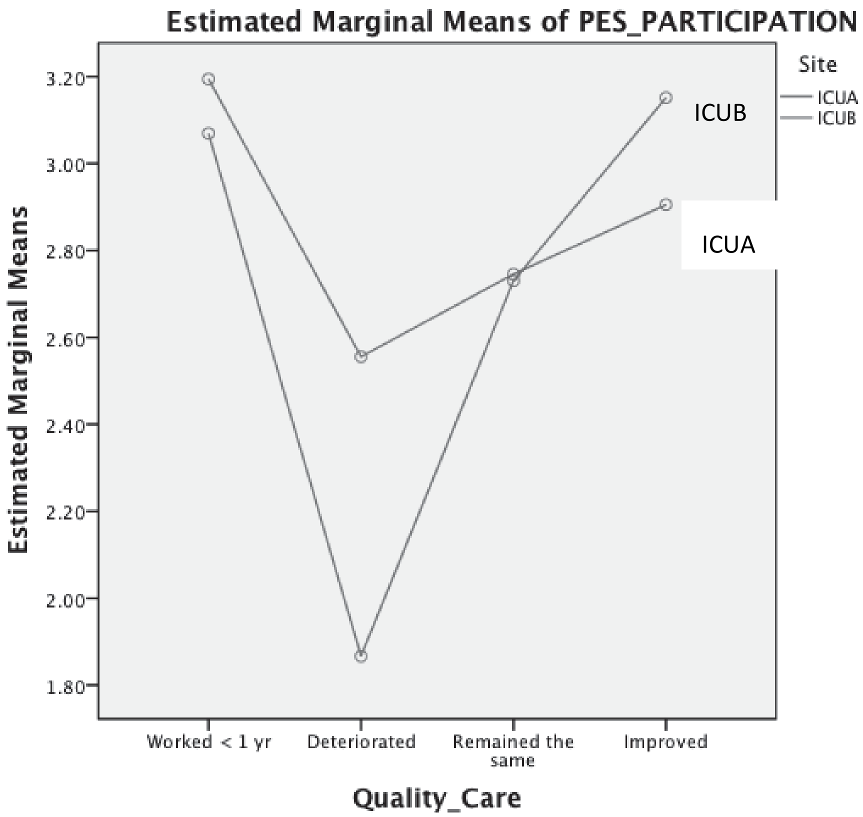
Homogeneous Subsets (PES_PARTICIPATION)

Tukey HSD [1,2,3]

Quality_Care	N	Subset		
		1	2	3
2.00 Deteriorated	16	2.3403		
3.00 Remained the same	66		2.7391	
4.00 Improved	43		3.0313	3.0313
1.00 Worked < 1 yr	20			3.1444
Sig.		1.000	.063	.767

1. Uses Harmonic Mean Sample Size = 26.506
2. The group sizes are unequal. The harmonic mean of the group sizes is used.
3. Type I error levels are not guaranteed.

Profile Plots



MBI_DP_Mean BY Site*OHS

Descriptive Statistics (Dependent Variable: MBI_DP)

Site	OHS	Mean	Std. Deviation	N
1.00 ICUA	1.00 Poor	2.8000	.	1
	2.00 Fair	1.2125	.95629	16
	3.00 Good	1.5686	.99146	51
	4.00 Excellent	1.4286	.65566	14
	Total	1.4902	.94132	82
2.00 ICUB	2.00 Fair	1.6000	1.11355	7
	3.00 Good	1.3333	.94292	45
	4.00 Excellent	.4727	.34955	11
	Total	1.2127	.94621	63
Total	1.00 Poor	2.8000	.	1
	2.00 Fair	1.3304	.99747	23
	3.00 Good	1.4583	.97113	96
	4.00 Excellent	1.0080	.71991	25
	Total	1.3697	.95024	145

Levene's Test of Equality of Error Variances[1] (Dependent Variable: MBI_DP)

F	df1	df2	Sig.
3.420	6	138	.004

1. Design: Intercept + Site + OHS + Site * OHS

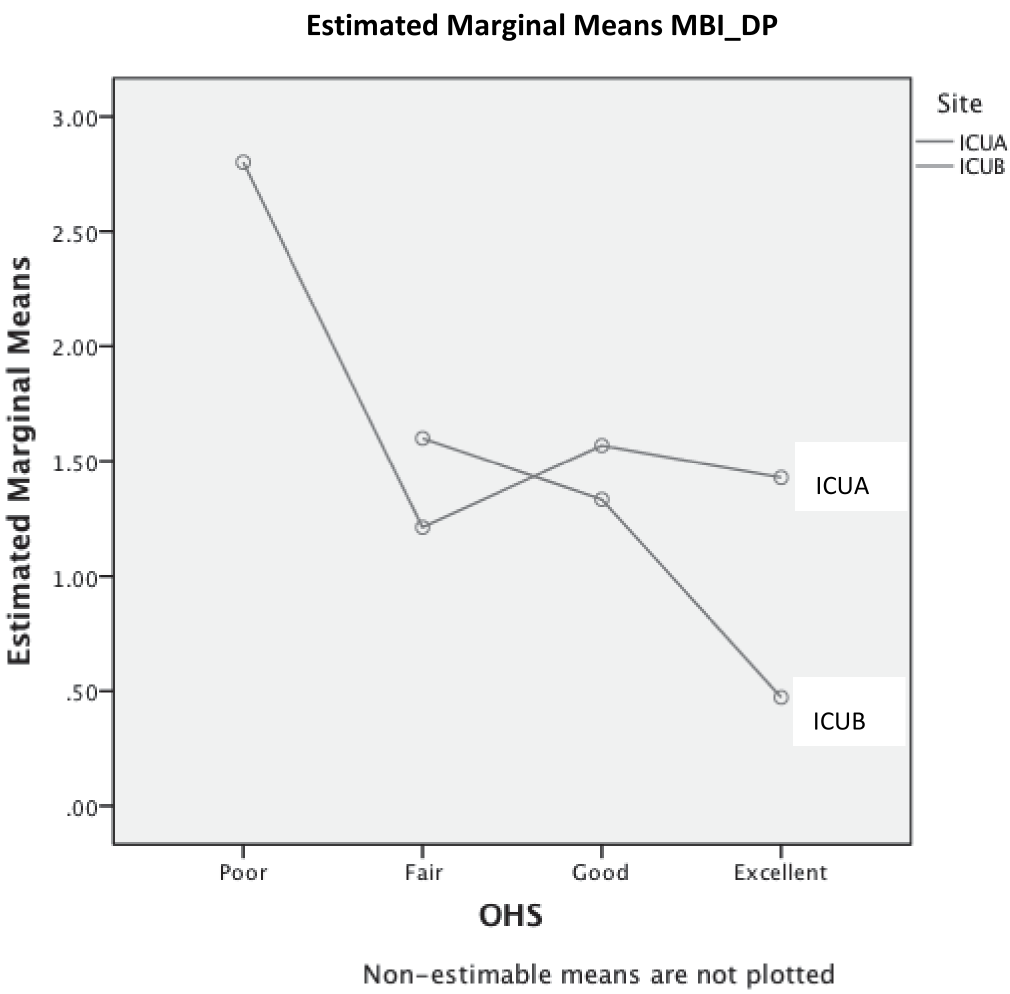
Tests of Between-Subjects Effects (Dependent Variable: MBI_DP)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13.789[1]	6	2.298	2.728	.016	.106
Intercept	53.262	1	53.262	63.234	.000	.314
Site	1.577	1	1.577	1.872	.173	.013
OHS	6.670	3	2.223	2.640	.052	.054
Site * OHS	5.030	2	2.515	2.986	.054	.041
Error	116.238	138	.842			
Total	402.040	145				
Corrected Total	130.026	144				

1. R Squared = .106 (Adjusted R Squared = .067)

NB. *Post hoc* tests were not performed for OHS because at least one group has fewer than two cases.

Profile Plots



PES_PARTICIPATION BY Site * Nursing_Satisfaction

Descriptive Statistics (Dependent Variable: PES_PARTICIPATION)

Site	Nursing_Satisfaction	Mean	Std. Deviation	N
1.00 ICUA	1.00 Very Dissatisfied	2.1667	.70711	2
	2.00 A Little Dissatisfied	2.7037	.61195	3
	3.00 Moderately Satisfied	2.8077	.39266	45
	4.00 Very Satisfied	2.9062	.53258	32
	Total	2.8267	.47090	82
2.00 ICUB	2.00 A Little Dissatisfied	2.6389	.56928	4
	3.00 Moderately Satisfied	2.5889	.48137	30
	4.00 Very Satisfied	3.1533	.40436	29
	Total	2.8519	.52610	63
Total	1.00 Very Dissatisfied	2.1667	.70711	2
	2.00 A Little Dissatisfied	2.6667	.53672	7
	3.00 Moderately Satisfied	2.7202	.44060	75
	4.00 Very Satisfied	3.0237	.48818	61
	Total	2.8376	.49402	145

Levene's Test of Equality of Error Variances[1] (Dependent Variable: PES_PARTICIPATION)

F	df_1	df2	Sig.
.816	6	138	.559

1. Design: Intercept + Site + Nursing_Satisfaction + Site * Nursing_Satisfaction

Tests of Between-Subjects Effects (Dependent Variable: PES_PARTICIPATION)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.048[a]	6	1.008	4.781	.000	.172
Intercept	231.973	1	231.973	1100.234	.000	.889
Site	.002	1	.002	.009	.924	.000
Nursing_Satisfaction	4.717	3	1.572	7.458	.000	.140
Site * Nursing_Satisfaction	1.795	2	.897	4.257	.016	.058
Error	29.096	138	.211			
Total	1202.716	145				
Corrected Total	35.144	144				

1. R Squared = .172 (Adjusted R Squared = .136)

Tukey HSD Post Hoc Tests (Dependent Variable: PES_PARTICIPATION)

(I) Nursing_Satisfaction	(J) Nursing_Satisfaction	Mean[1] Difference (I-J)	Std. Error[2]	Sig.	95% CI Lower	95% CI Upper
1.00 Very Dissatisfied	2.00 A Little Dissatisfied	-.5000	.36816	.528	-1.4574	.4574
	3.00 Moderately Satisfied	-.5535	.32898	.337	-1.4091	.3020
	4.00 Very Satisfied	-.8570	.32996	.050	-1.7151	.0011
2.00 A Little Dissatisfied	1.00 Very Dissatisfied	.5000	.36816	.528	-.4574	1.4574
	3.00 Moderately Satisfied	-.0535	.18147	.991	-.5254	.4184
	4.00 Very Satisfied	-.3570	.18324	.213	-.8335	.1195
3.00 Moderately Satisfied	1.00 Very Dissatisfied	.5535	.32898	.337	-.3020	1.4091
	2.00 A Little Dissatisfied	.0535	.18147	.991	-.4184	.5254
	4.00 Very Satisfied	-.3035*	.07917	.001	-.5094	-.0976
4.00 Very Satisfied	1.00 Very Dissatisfied	.8570	.32996	.050	-.0011	1.7151
	2.00 A Little Dissatisfied	.3570	.18324	.213	-.1195	.8335
	3.00 Moderately Satisfied	.3035*	.07917	.001	.0976	.5094

1. Based on observed means.
2. The error term is Mean Square (Error) = .211.

Homogeneous Subsets (Dependent Variable: PES_PARTICIPATION)

Tukey HSD[1,2,3]

Nursing_Satisfaction	N	Subset 1	Subset 2
1.00 Very Dissatisfied	2	2.1667	
2.00 A Little Dissatisfied	7	2.6667	2.6667
3.00 Moderately Satisfied	75	2.7202	2.7202
4.00 Very Satisfied	61		3.0237
Sig.		.165	.539

1. Uses Harmonic Mean Sample Size = 5.947.
2. The group sizes are unequal. The harmonic mean of the group sizes is used.
3. Type I error levels are not guaranteed.

Profile Plots