









## A health economic analysis of ‘A novel implementation of best evidence practice for incontinence-associated dermatitis’ (IMBED)

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### ABSTRACT

**Aim:** To assess resource usage and other outcomes of implementing a bundle of evidence-based, clinician-led incontinence-associated dermatitis interventions, ‘IMBED’ intervention.

**Methods:** Patients with incontinence recruited from 6 public hospitals in Australia in pre-intervention (1 February-31 March 2020) and post-intervention periods (1 May-30 June 2021). For the health economic study, nurses/research officers recorded resource usage for a random sample of incontinence care episodes each week.

**Results:** 799 patients with incontinence (9645 incontinence care episodes). There were significant differences in the proportion of incontinence care episodes using specific product-types between the pre- and post-intervention groups, with the greatest increase for treatment/prevention products (55.2 % versus 82.8 %;  $p < 0.001$ ) and decrease for underpads/bed pads (28.5 % versus 12.9 %;  $p < 0.001$ ). There was a significant decrease in mean total product cost per incontinence care episode between these groups (AU\$2.64 versus AU\$2.35;  $p < 0.001$ ). There was a significant increase in mean staff cost per incontinence care episode between these groups (AU\$9.65

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versus AU\$10.09;  $p = 0.001$ ), driven by increases in the mean number of staff and time spent per episode. There was an increase in mean total cost per incontinence care episode (AU\$0.15) between these groups but not significant ( $p = 0.344$ ).

**Conclusion:** There was a significant decrease in mean total product cost per incontinence care episode in the intervention group. There was no significant change in mean total incontinence care cost per episode associated with the intervention, suggesting hospitals adopted IMBED with minimal extra expenses. There was streamlined resource usage and reductions in products not supported by evidence-based guidelines.

## 1. Introduction

Incontinence-associated dermatitis (IAD) is skin damage associated with prolonged urine/stool exposure [1]. Over the last two decades, substantial evidence has emerged regarding proactive measures to avert skin breakdown among individuals experiencing incontinence [2]. This marks a significant shift from simply treating incontinence skin problems to focusing on their prevention. This was catalysed by enhanced understanding of the etiological underpinnings of IAD such as excessive moisture, microclimate, enzymatic influences, and friction-induced elements [3]. IAD prevention encompasses various approaches, including utilisation of dermatological emollients to protect the epidermal barrier, advanced moisture-absorbing incontinence pads, adherence to skin care practices, and incontinence management [1]. IAD best practice [4] includes clinicians having the knowledge and skills to prevent/treat breakdown in skin integrity, and appropriate resources available [1,5]. To ensure the latter, healthcare executives/policymakers need reliable information on the value of products and clinician time used so these costs can be compared to the benefits and thus evaluate whether their use can be supported.

IAD prevalence varies by healthcare setting [6], from 3 to 23 % in residential aged care facilities to 15–50 % in acute care [7]. IAD in patients with incontinence is associated with significant increases in hospital length of stay (LoS) and resource usage (costs) compared to patients with incontinence who do not require IAD treatment [8,9]. Common health conditions among patients with incontinence are ageing-related frailty, mental health including depression, and heightened risks of infections/injuries such as recurring urinary tract infections (UTIs) and falls, which contribute to the greater likelihood of skin breakdown during admissions, protracted LoS and mortality rates among this group [10,11].

Identification of incontinence skin breakdown, implementation of best practices, monitoring skin breakdowns as resources are employed, and tracking costs have gained much attention recently [1,4,9]. The main reasons for this are the increased number of hospital admissions of high-risk patients (e.g. those with ageing-related frailty, UTI complications, and falls) due to population ageing, international nursing agreement on evidence-based prevention/treatment for skin breakdowns, support for documenting incontinence/management of skin breakdowns in medical records, and investment in the development of interventions and assessing their effectiveness/cost-effectiveness [1,2,9,12].

Until recently, generating estimates of the cost of incontinence skin breakdowns for health systems has been challenging due to lack of an International Classification of Diseases (ICD) code for IAD [5,8]. These costs have usually been calculated using several ICD-10 codes for incontinence (e.g. ICD-10-Clinical Modification [CM]/Procedure Coding System [PCS] in the United States; ICD-10-Australian Modification [AM] and hospital procedure codes in Australia) plus data on the number and value of products, pathology, antibiotics and antifungal medications, and staff used to care for patients [13]. This “bottom-up” costing has normally been completed by staff providing incontinence/skin breakdown care [9,14,15]. Introduction of the ICD-10-CM (and AM) diagnosis code, “L24. A2 Irritant contact dermatitis due to faecal, urinary or dual incontinence”, occurred after the current study’s timeframe (<http://www.icd10data.com/ICD10CM/Codes>).

It is recognised that evidence-based guidelines for IAD management

need to be better implemented and evaluated in public hospitals internationally [1,5]. This current health economic (HE) study, which was imbedded in an implementation science study aimed at implementing evidence-based guidelines to prevent/manage IAD [5], aimed to (a) assess the main resources used (costs) for skin breakdown prevention in patients with incontinence episodes pre- and post-implementation of a bundle of evidence-based, clinician-driven IAD interventions (called ‘A Novel implementation of best available evidence into practice for incontinence-associated dermatitis’ [IMBED]) in several public hospitals in New South Wales (NSW), Australia [5], using micro-level data [16, 17]; (b) assess other outcomes such as LoS; and (c) identify any IMBED-associated cost reductions. The study highlights how evidence-based interventions for incontinence/skin breakdown can alter resource utilisation patterns, enabling cost reductions.

## 2. Materials and methods

### 2.1. Design and setting

This was a prospective, pre-and-post HE study (quasi-experimental) with different samples recruited in the IMBED study phases [5]. It is important to note that whilst the original protocol includes plans for a cost-effectiveness analysis (CEA) and a cost-utility analysis (CUA), these were not feasible due to several limitations. The effectiveness data were either not significant or unavailable at the time of economic analysis, and quality of life (QoL) data showed a reduction in QoL in the post-intervention cohort, likely confounded by greater disease severity in that cohort. Additionally, different patient samples were used for the cost, outcome (IAD), and QoL data, limiting the validity of summary measures such as ICERs. As a result, a detailed costing analysis and cost-consequence analysis (CCA) were conducted, focusing on assessments of the economic and clinical impacts associated with the implementation of IMBED.

The IMBED study was set in 18 wards in six public hospitals within five local health districts in NSW [5]. There were four metropolitan hospitals, with three 28-bed wards (six aged care/geriatric wards, two rehabilitation wards, two gastroenterology wards, one palliative care ward, and one general medical ward), as well as two regional hospitals, with three 15-bed wards (two surgical wards, two medical wards, one rehabilitation ward, and one intensive care ward). The approximate nurse-patient ratio was 1:4.

The HE study forming this paper examined information collected by nurses/ROs using a purpose-built Healthcare Resource Use Collection Tool (HRUCT), which recorded products used and staff time for managing incontinence and preventing skin breakdowns prior to and post IMBED implementation, and LoS.

The main effect of the clinical study was the difference in IAD prevalence pre- and post-IMBED intervention. Barakat-Johnson et al. (2024) outlines the IMBED study including sample size, participants, IAD prevalence audit tool and results [18]. The prevalence statistic is reported in this paper (found in Ref. [18]) to enable a comparison of this main effect with the costs.

### 2.2. Sample size, criteria and participants

Barakat-Johnson et al. (2021) determined the sample size using

hospital bed occupancy rates, size of wards, and inclusion/exclusion criteria [5]. Inclusion criteria was any patient 18 years or older with incontinence on a study ward.

For the HE study, patients were identified every shift by nurses and included in the study, following verification they met inclusion criteria and were informed about the study (opt-out consent available).

### 2.3. Intervention

IMBED consisted of a bundle of evidence-based [1], clinician-driven interventions for IAD, such as continence screening and assessment, Ghent Global IAD Categorisation Tool [GLOBIAD] [19]; barrier cream cloth application (Comfort Shield® Barrier Cream Cloths); removing bed protectors such as drawsheets, Kylies [20], multiple pads and underlayers; and using suitable incontinence aids [5].

### 2.4. Outcomes

Outcomes explored are healthcare resource use, costs for incontinence care episodes in pre- and post-IMBED periods, and LoS.

### 2.5. Measures

Healthcare resource usage was collected by nurses/research officers (ROs) for a random sample of incontinence care episodes each week. IAD prevalence audits were also undertaken whereby skin and continence assessments were conducted on all patients at a random ward at each hospital each week.

Nurses/ROs used the HRUCT developed by the research team to document, for patients, the type and number of products used, staff involved in incontinence care episodes and time taken. Data included date and time of incontinence care episodes, type of incontinence treated, type (brand) and number of products used, purpose, time taken to deliver care, and type and number of staff. Information about the patient's admission (such as LoS, IAD presence, and outcome post-admission), and characteristics were also collected.

### 2.6. Procedures

The HRUCT was completed by nurses/ROs pre- (1 February 2020–31 March 2020) and post-IMBED periods (1 May 2021–30 June 2021). Training and assistance were provided by clinical leads on how and when to complete the HRUCT, including it was only to be completed for patients with incontinence. Resources used during incontinence care episodes were recorded for nursing shifts and until patients were transferred from study wards/hospitals to another location, discharged from hospitals or died. A list of product categories (e.g. skin cleansers) and brands (e.g. Cetaphil® Gentle Skin Cleanser, Kleenex® Hand and Body Shower Gel, and Bath in Bed Wipes) were provided in the HRUCT to assist with entering information.

### 2.7. Ethical considerations

The study was approved by the Human Research Ethics Committee of the Sydney Local Health District (RPAH Zone) (2019/ETH08742). Data on patient records were deidentified before analysis.

### 2.8. Analysis

An assessment of the type, amount, and value of the products and staff time used for incontinence and skin breakdown management in pre- and post-IMBED intervention periods was conducted from the healthcare provider standpoint. Microsoft Excel was used to organise patient characteristics and HRUCT data, and STATA version 16 [21] to undertake data analysis. Significance tests (t-tests,  $\chi^2$ , Kruskal-Wallis) were conducted at the 5 % significance level.

### 2.9. Healthcare resource costs

Unit costs were sourced from each hospital for the products used in incontinence care episodes, including skin cleansers (such as Bed Bath™ lite, Microshield® Skincare Cleanser, and Rediwipes), prevention/treatment products (such as MoliCare® Skin Barrier Cream and Comfort Shield® Barrier Cream Cloths), other creams (Sorbolene, Sudocrem® and Zinc oxide cream), pads (such as Abena® Abri-Form, MoliCare® All-In-Ones, and Ontex iD Pants), and underpads/bed pads (Bluey disposable bed pads, Bosco Medical Australia Underpads, and MediFlex Industries Super Absorbent Polymer Underpads). Hospitals normally source most of this material from a common cost catalogue rather than individual supplier direct purchases (thus cost prices are fairly consistent). Staff hourly wage rates were based on NSW State Awards (Public Health System Nurses' & Midwives' (State) Award 2019 [22], NSW Health Employees (State) Award 2019 [23], and NSW Health Service Health Professionals (State) Award 2019 [24]).

Not all episodes of incontinence skin care in an admission were included in the data collection. Nurses/ROs recorded only a random sample of episodes of incontinence care for patients. Furthermore, some days of a patient's admission could have occurred outside the collection period. Because each admission is not representative of all episodes of incontinence care, it was not possible to compare the resources used (costs) at the admission level. Thus, the study compares product utilisation, time spent by staff providing care, and costs per episode of incontinence care. All products and staff costs were valued using 2021 Australian prices (AUD\$).

## 3. Results

### 3.1. Patient characteristics

A total of 799 admitted patients with recorded incontinence formed the HE study sample (441 pre- and 358 post-intervention) (Table 1). There were no statistical differences between these groups by mean age (81.1 years), number of comorbidities (3.2 conditions) or gender (female: 56.1 % of the sample) (Table 1). However, there were differences between these groups regarding wards admitted to ( $p = 0.001$ ) and outcome post-hospitalisation ( $p = 0.006$ ). A smaller percentage of patients were admitted to medical wards and discharged to nursing homes in the pre- than in the post-intervention period (13.2 % versus 21.2 % for the former and 24.9 % versus 36.6 % for the latter), suggesting patients were more dependent on care in the latter period. Additionally, patients experienced a longer LoS in the post-intervention period (23.1 versus 30.5 days), indicating higher acuity (Table 1).

There were 9645 incontinence care episodes reported for all patients (5821 episodes in the pre- and 3824 in the post-intervention period), and most were for urinary incontinence (6076; 63.0 %). There were significant differences in the type of incontinence that patients experienced per episode between the two periods (Appendix Table 1). A higher percentage of care episodes were for faecal incontinence (12.3 % versus 10.4 %) and both urinary and faecal incontinence (22.1 % versus 19.4 %) in the pre-compared to the post-intervention period.

### 3.2. Product utilisation

Product categories reported for the incontinence care episodes are presented in Table 2. There was a significant increase in the percentage of episodes reporting utilisation of treatment/prevention products (3214; 55.2 % versus 3165; 82.8 % = difference of 27.6 %;  $p < 0.001$ ) and incontinence pads (5646; 97.0 % versus 3747; 98 % = difference of 1.0 %;  $p = 0.003$ ) from pre- to post-intervention. There was a significant decrease in the percentage of episodes reporting utilisation of underpads/bed protectors (1657; 28.5 % versus 494; 12.9 % = difference of 15.6 %;  $p < 0.001$ ); skin cleansers (5036; 86.5 % versus 3143; 82.2 % = difference of 4.3 %;  $p < 0.001$ ); and creams such as Sorbolene,

**Table 1**  
Healthcare resource use patient characteristics.

	All patients N = 799 n (%)	Pre-intervention N = 441 n (%)	Post-intervention N = 358 n (%)	Difference between pre and post p-value
<b>Age</b>				
Mean	81.1	80.9	81.3	0.555 <sup>a</sup>
Median	83	83	83	0.706 <sup>b</sup>
Range	23–103	23–103	33–103	0.158 <sup>b</sup>
20–29 years	2 (0.3)	2 (0.5)	0 (0)	
30–39 years	2 (0.3)	0 (0)	2 (0.6)	
40–49 years	8 (1.0)	3 (0.7)	5 (1.4)	
50–59 years	27 (3.4)	15 (3.4)	12 (3.4)	
60–69 years	64 (8.0)	39 (8.8)	25 (7.0)	
70–79 years	185 (23.2)	98 (22.2)	87 (24.3)	
80–89 years	338 (42.3)	200 (45.4)	138 (38.6)	
90–99 years	168 (21.0)	81 (18.4)	87 (24.3)	
100–109 years	5 (0.6)	3 (0.7)	2 (0.6)	
<b>Gender</b>				
Female	448 (56.1)	241 (54.7)	207 (57.8)	0.369 <sup>b</sup>
Male	351 (43.9)	200 (45.4)	151 (42.2)	
<b>Number of comorbidities</b>				
Mean	3.2	3.1	3.3	0.142 <sup>a</sup>
Median	3.0	2.0	3.0	0.101 <sup>b</sup>
Range	0–12	0–12	0–10	
<b>Ward</b>				
Acute geriatrics	384 (48.1)	209 (47.4)	175 (48.9)	
Intensive care unit	18 (2.3)	12 (2.7)	6 (1.7)	
Medical	134 (16.8)	58 (13.2)	76 (21.2)	
Palliative care	26 (3.3)	19 (4.3)	7 (2.0)	
Respiratory & gastroenterology	80 (10.0)	58 (13.2)	22 (6.2)	
Sub-acute and rehabilitation	113 (14.1)	65 (14.7)	48 (13.4)	
Surgery	44 (5.5)	20 (4.5)	24 (6.7)	
<b>Outcome post-hospitalisation</b>				
Discharged home	351 (43.9)	211 (47.9)	140 (39.1)	0.006 <sup>c</sup>
Discharged to group home	3 (0.4)	0 (0)	3 (0.8)	
Discharged to nursing home	241 (30.2)	110 (24.9)	131 (36.6)	
Discharged to rehabilitation	3 (0.4)	0 (0)	3 (0.8)	
Discharged to respite care	10 (1.3)	5 (1.1)	5 (1.4)	
Deceased	92 (11.5)	56 (12.7)	36 (10.1)	
Transferred to other hospital	93 (11.6)	55 (12.5)	38 (10.6)	
Transferred to another ward	6 (0.8)	4 (0.9)	2 (0.6)	
<b>Length of stay (LoS), days<sup>d</sup></b>				
Mean (SD)	26.4 (33.0)	23.1 (24.9)	30.5 (40.5)	0.002 <sup>e</sup>
Median	16	14	18	0.008 <sup>c</sup>
Range	1–398	1–160	1–398	
<b>Median LoS (days) by gender</b>				
Female	15	14	17	0.523 <sup>f</sup>
Male	17	14	22	
<b>Median LoS (days) by age groups</b>				
20–29 years	26	26	NA	0.003 <sup>g</sup>
30–39 years	200	NA	200	
40–49 years	15	52	14	
50–59 years	37	29	64	
60–69 years	27	20	56	
70–79 years	14	11	15	
80–89 years	15	13	18	
90–99 years	16	15	18	
100–109 years	15	8	48	

**Notes.**<sup>a</sup> Two sample *t*-test showed no significant difference between the pre- and post-intervention subsamples.<sup>b</sup> Chi<sup>2</sup> test showed no significant differences between the pre- and post-intervention subsamples.<sup>c</sup> Chi<sup>2</sup> tests showed significant differences between the pre- and post-intervention subsamples.<sup>d</sup> N = 797 patients with LoS data: 358 patients in the pre-intervention period and 439 patients in the post-intervention period.<sup>e</sup> Two sample *t*-test showed significant differences between the pre- and post-intervention subsamples.<sup>g</sup> Kruskal-Wallis test showed statistically significant differences between the pre- and post-intervention subsamples.<sup>f</sup> Kruskal-Wallis test showed no statistically significant differences between the pre- and post-intervention subsamples.

Sudocrem®, and Zinc oxide cream (642; 11.0 % versus 10; 0.3 % = difference of 10.7 %;  $p < 0.001$ ) from pre-to post-intervention.

Mean number of products used at the episode level is reported in Table 3. There was a significant decrease in mean number of skin cleansers used over the two periods (4.0 versus 3.0 products; difference of 1.0 product;  $p < 0.001$ ). Additionally, there was a significant increase in the number of treatment/prevention products used from pre-to post-intervention (0.9–1.5 products; difference of 0.6 products;  $p < 0.001$ ), in

line with IMBED aims.

Utilisation of products by brands is reported in Table 4. Rediwipes were the most common cleansing product used in both periods, 4122 (70.8 %) and 2591 (67.7 %) of episodes reported usage in the pre- and post-intervention periods, respectively. Whilst the most used prevention/treatment product was Comfort Shield® Barrier Cream Cloths in both periods, there was a 34 % increase in episodes reporting their use post-intervention (2809; 48.3 % versus 3050; 82.3 % of episodes). A

**Table 2**  
Proportion of incontinence episodes reporting use of products categories.

	All Records N = 9645 n (%)	Pre-intervention N = 5821 n (%)	Post-intervention N = 3824 n (%)	Difference % (p-value)
Skin cleansers <sup>a</sup>	8179 (84.8)	5036 (86.5)	3143 (82.2)	-4.3 (<0.001)
Prevention/treatment products <sup>a</sup>	6379 (66.1)	3214 (55.2)	3165 (82.8)	27.6 (<0.001)
Other creams <sup>a</sup>	652 (6.8)	642 (11.0)	10 (0.3)	-10.7 (<0.001)
Pads <sup>a</sup>	9393 (97.4)	5646 (97.0)	3747 (98.0)	1.0 (0.003)
Underpad/bed protectors <sup>a</sup>	2151 (22.3)	1657 (28.5)	494 (12.9)	-15.6 (<0.001)

Notes.

<sup>a</sup> Includes sorbolene, sudocream and other zinc creams.

<sup>a</sup> Statistical proportion tests showed statistically significant differences between pre- and post-intervention.

**Table 3**  
Number of products used per episode of incontinence care<sup>a</sup>.

		All Records N = 9645	Pre-intervention N = 5821	Post-intervention N = 3824	Difference (p-value)
Skin cleansers <sup>b</sup>	Mean	3.63	4.04	3.01	-1.03 (<0.001)
	Median	2.0	3.0	2.0	
	Range	0-71	0-71	0-31	
Prevention/treatment products <sup>b</sup>	Mean	1.10	0.85	1.48	0.63 (<0.001)
	Median	1.0	1.0	1.0	
	Range	0-16	0-16	0-14	
Other creams <sup>b</sup>	Mean	0.07	0.11	0.002	-0.11 (<0.001)
	Median	0	0	0	
	Range	0-2	0-2	0-1	
Pads <sup>b</sup>	Mean	1.01	1.01	0.99	-0.02 (<0.001)
	Median	1.0	1.0	1.0	
	Range	0-4	0-4	0-3	
Underpads/bed protectors <sup>b</sup>	Mean	0.25	0.32	0.13	-0.19 (<0.001)
	Median	0.0	0.0	0.0	
	Range	0-4	0-4	0-3	

Notes.

<sup>a</sup> Includes sorbolene, sudocream and other zinc creams.

<sup>a</sup> In records where the number of products used was missing, the mean number of products was imputed for each product and for the pre-intervention and post-intervention groups separately.

<sup>b</sup> Statistical t-tests showed statistically significant differences between pre- and post-intervention.

reduction in almost all other prevention/treatment products was also observed. Importantly, there were no incontinence care episodes in the post-intervention period using Sudocrem® or Zinc oxide cream and a sizable reduction in Sorbolene use (412; 7.1 % versus 10; 0.3 % = difference of 6.8 %), indicating adherence to intervention guidelines. There was a reduction in all underpads/bed protectors applied during the study, with the largest reduction occurring for Blueys (1376; 23.6 % versus 471; 12.3 % = difference of 13.3 %).

### 3.3. Staff utilisation

There was a significant increase in mean number of staff (mostly Registered Nurses) attending to each incontinence care episode across the periods, from 1.6 to 1.7 staff care episodes (Table 5). There was no significant difference in time taken for each care episode between the two samples (Table 5).

### 3.4. Costs

Table 6 presents the total cost for products, staff and all resources used per incontinence care episode, described as mean and median costs across all episodes. Mean overall cost of products was AU\$2.64 in the pre- and AU\$2.35 in the post-intervention period, corresponding to a significant decrease of AU\$0.29 ( $p < 0.001$ ). This reduction was driven by significant decreases in the cost of other creams (reduction of AU \$0.28 per episode of care;  $p < 0.001$ ) and underpads/bed protectors (reduction of AU\$0.10 per episode of care;  $<0.001$ ) from the pre-to post-intervention period.

Mean overall staff cost per care episode was AU\$9.82, with episodes in the pre-intervention period having a significantly lower cost of AU

\$9.65 compared to AU\$10.09 in the post-intervention period ( $p = 0.001$ ) (Table 6). However, more staff could have been needed for higher care of patients in the post-intervention period.

While there was an increase in mean total costs between the two samples (AU\$12.30 versus AU\$12.45 per episode), it was not significant ( $p = 0.344$ ).

### 3.5. Hospital-acquired IAD prevalence data

The sample comprised 758 patients with incontinence (364 pre- and 394 post-intervention). Patient characteristics in these periods were similar, except the post-intervention group had poorer health profiles including a higher percentage of bed-bound and doubly incontinent patients. A higher percentage of patients had hospital-acquired IAD in the pre-than in the post-intervention period (6.7 % versus 4.3 %) but the difference (2.4 %) was not significant ( $p = 0.159$ ) [18].

## 4. Discussion

IMBED reduced hospital-acquired IAD prevalence [18], demonstrating clinical effectiveness even though it was not statistically significant, amidst challenges such as higher patient acuity, double incontinence prevalence, and COVID-19. The study found favourable (and statistically significant) changes in the type of products used in incontinence care and related costs from the clinical standpoint.

Significant changes in product usage were found; specifically, a decrease in the percentage of care episodes using Sorbolene, Sudocrem® and Zinc oxide creams (and these costs), with the largest cost reduction in Sorbolene, Sudocrem® and Zinc oxide creams as well as an increase in Comfort Shield® Barrier Cream Cloths usage, suggesting IMBED uptake

**Table 4**  
Product usage episode (proportion of patients using each item per episode).

	All patients N = 9645 n (%)	Pre-intervention N = 5821 n (%)	Post-intervention N = 3824 n (%)
<b>Skin cleansers</b>			
3M™ Avagard™ General Hand And Body Wash	40 (0.4)	27 (0.5)	13 (0.3)
Bed Bath™ lite	1246 (12.9)	830 (14.3)	416 (10.9)
Cetaphil® Gentle Skin Cleanser	1 (0.01)	0 (0.0)	1 (0.03)
Kleenex® Hand and Body Shower Gel	47 (0.5)	44 (0.8)	3 (0.1)
Microshield® Skincare Cleanser	613 (6.4)	312 (5.4)	301 (7.9)
MoliCare® Skin Cleansing Foam	72 (0.8)	71 (1.2)	1 (0.0)
Rediwipes	6713 (69.6)	4122 (70.8)	2591 (67.7)
<b>Prevention/treatment products</b>			
Amolin® Baby Cream	14 (0.2)	14 (0.2)	0 (0.0)
3M™ Avagard™ General Moisturising Barrier Lotion	38 (0.4)	35 (0.6)	3 (0.1)
Bed in Bath Wipes	4 (0.0)	2 (0.0)	2 (0.1)
3M™ Cavilon™ No Sting Barrier Film 1 mL Wipe	24 (0.3)	24 (0.4)	0 (0.0)
Clotrimazole	16 (0.2)	16 (0.3)	0 (0.0)
Dimethicone	7 (0.1)	7 (0.1)	0 (0.0)
Indwelling catheters (IDC) <sup>a</sup>	78 (0.8)	43 (0.7)	35 (0.9)
Lanolin	1 (0.0)	1 (0.0)	0 (0.0)
MoliCare® Skin Barrier Cream	254 (2.6)	254 (2.6)	0 (0.0)
Comfort Shield® Barrier Cream Cloths	5959 (61.8)	2809 (48.3)	3050 (82.3)
Vitamin A cream	2 (0.0)	2 (0.0)	0 (0.0)
Uridome	3 (0.0)	0 (0.0)	3 (0.1)
<b>Other creams</b>			
Sorbolene	422 (4.4)	412 (7.1)	10 (0.3)
Sudocrem®	218 (2.3)	218 (3.8)	0 (0.0)
Zinc oxide cream	27 (0.3)	27 (0.5)	0 (0.0)
<b>Pads</b>			
Abena® Abri-Flex Pad	53 (0.6)	4 (0.1)	49 (1.3)
Abena® Abri-Form Pad	45 (0.5)	22 (0.4)	23 (0.6)
Abena® Abri-San Premium Pad	31 (0.3)	28 (0.5)	3 (0.1)
U by Kotex® Super Pads	9 (0.1)	9 (0.2)	0 (0.0)
MoliCare® All-In-One Slips	4465 (46.3)	2590 (44.5)	1875 (49.0)
iD Pants	4807 (49.8)	3004 (51.6)	1803 (47.2)
Lille® Suprem Light	7 (0.1)	0 (0.0)	7 (0.2)
<b>Under pads/bed pads</b>			
Bluey	1847 (19.2)	1376 (23.6)	471 (12.3)
Green protector	154 (1.6)	152 (2.6)	2 (0.1)
Underpad with Super Absorbent Polymer (SAP)	150 (1.6)	129 (2.2)	21 (0.6)

<sup>a</sup> Indwelling catheters (IDC): MDevices®; Dover™ Silicone Foley Catheters; Cliny 3 Way Haematuria Balloon Catheter; Advance Plus™ Intermittent Catheter System (12 fg or 14 fg); ConvaTec Foley 2 Way Silicone Catheter. Although IDC could be classified in another way, they account for <1 % of the sample and thus any change has a very negligible effect on results.

was positive, as was the decreased use of less desirable products.

Despite initial concerns regarding the perceived expense of Comfort Shield® Barrier Cream Cloths usage, our findings reveal a significant increase in their usage post-intervention (from 48.3 % to 82.3 % of episodes) without a corresponding increase in overall costs. A decrease in product costs overall was observed, challenging the notion that opting for only cheaper alternatives necessarily leads to cost savings/operational efficiencies. These findings emphasise the importance of adopting a strategic approach to procurement. Thus, healthcare providers should consider not only the upfront costs but also the long-term benefits and efficacy of products such as Comfort Shield® Barrier Cream Cloths. The other notion challenged by this finding is that lower cost equates to

**Table 5**  
Nurses and other staff recorded at each episode of incontinence care<sup>^</sup>, the time taken for staff to deliver those episodes of care<sup>#</sup> and mean labour costs per episode of care<sup>^</sup>.

	All Records N = 9645	Pre-intervention N = 5821	Post-intervention N = 3824
<b>Percentage of records by staff type n (%)</b>			
Registered nurse (RN)	8653 (89.7)	5217 (89.6)	3436 (89.9)
Enrolled nurse (EN)	780 (8.1)	394 (6.8)	386 (10.1)
Assistant in nursing (AIN)	916 (9.5)	607 (10.4)	309 (8.1)
Wardsperson	657 (6.8)	400 (6.9)	257 (6.7)
Endorsed enrolled nurse (EEN)	788 (8.2)	481 (8.3)	307 (8.0)
Student nurse	302 (3.1)	114 (2.0)	188 (4.9)
Security guard (SG)	18 (0.2)	3 (0.1)	15 (0.4)
Nurse unit manager	7 (0.1)	3 (0.1)	4 (0.1)
Clinical nurse consultant (CNC)	1 (0.0)	1 (0.0)	0 (0.0)
Clinical nurse specialist (CNS)	2 (0.0)	1 (0.0)	1 (0.0)
Clinical nurse educator (CNE)	6 (0.1)	3 (0.1)	0 (0.1)
Physiotherapist	8 (0.1)	6 (0.1)	2 (0.1)
Occupational therapist	4 (0.0)	2 (0.0)	2 (0.1)
<b>Total staff per episode of care</b>			
Mean <sup>b</sup>	1.6	1.6	1.7
Median	2.0	2.0	2.0
0 n (%)	10 (0.1)	6 (0.1)	4 (0.1)
1 n (%)	3603 (37.4)	2319 (39.8)	1284 (33.6)
2 n (%)	5576 (57.8)	3307 (56.8)	2269 (59.3)
3 n (%)	169 (1.8)	58 (1.0)	111 (2.9)
4 n (%)	19 (0.2)	8 (0.1)	11 (0.3)
5 n (%)	9 (0.1)	1 (0.0)	8 (0.2)
6 n (%)	2 (0.0)	0 (0.0)	2 (0.1)
Missing n (%)	255 (2.7)	122 (1.3)	135 (3.5)
<b>Total staff time (minutes)</b>			
Mean <sup>c</sup>	9.2	9.1	9.3
Median	10	10	10
Range	1–60	1–60	1–45
<b>Time (minutes)</b>			
0–4 n (%)	315 (3.3)	190 (3.3)	125 (3.3)
5–9 n (%)	3424 (35.5)	2050 (35.2)	1374 (35.9)
10–14 n (%)	3987 (41.3)	2423 (41.6)	1564 (40.9)
15–19 n (%)	915 (9.5)	506 (8.7)	409 (10.7)
20–24 n (%)	373 (3.9)	240 (4.1)	133 (3.5)
25–30 n (%)	32 (0.3)	21 (0.4)	11 (0.3)
30+ n (%)	64 (0.7)	42 (0.7)	22 (0.6)
Missing n (%)	535 (5.6)	349 (6.0)	186 (4.9)
<b>Mean staff costs per episode of care (AU \$)</b>			
Registered nurse (RN)	8.17	8.02	8.39
Enrolled nurse (EN)	0.42	0.35	0.52
Assistant in nursing (AIN)	0.41	0.44	0.37
Wardsperson	0.37	0.38	0.36
Endorsed enrolled nurse (EEN)	0.39	0.40	0.38
Student nurse	0.00	0.00	0.00
Security guard (SG)	0.02	0.00	0.03
Nurse unit manager	0.01	0.00	0.02
Clinical nurse consultant (CNC)	0.00	0.00	0.00
Clinical nurse specialist (CNS)	0.01	0.00	0.00
Clinical nurse educator (CNE)	0.01	0.00	0.01
Physiotherapist	0.01	0.01	0.00
Occupational therapist	0.01	0.01	0.00
<b>Total<sup>d</sup></b>	<b>9.82</b>	<b>9.65</b>	<b>10.09</b>

Notes.

<sup>^</sup> In records where the type of staff member was missing, it was assumed that the episode was attended to by an RN. If more than one type was missing, one staff member was assumed to be an RN and the other staff member either an Enrolled Nurse (EN) or Nursing Assistant (AIN) based on the other episode of care records for that admission. In records where the number of staff was missing (n = 255),

the mean number of staff was imputed for the pre-intervention and post-intervention groups separately (pre-intervention, 1.604; post-intervention, 1.694).

# In records where the time taken for an episode of care was missing (n = 536), the mean time was imputed for the pre-intervention and post-intervention samples separately (pre-intervention, 9.13 min; post-intervention, 9.29 min).

<sup>a</sup> Percentages do not add to 100 as multiple nurses can be used for the same record.

<sup>b</sup> T-test showed a statistically significant increase of 0.1 staff members per episode of care from pre- to post-intervention (p < 0.001).

<sup>c</sup> T-test showed no statistically significant difference between the pre- and post-intervention populations.

<sup>d</sup> T-test showed a statistically significant increase of \$0.44 per episode of care from pre- to post-intervention (p = 0.001).

lower patient outcomes/experiences. The decrease in product costs and increase in staff costs have both had a positive impact on patient outcomes and experiences, see Barakat-Johnson et al. [25].

Evidence-based guidelines recommend to cleanse, protect, and restore skin following an incontinence episode [1,26]. This three-step approach employed in IMBED can yield favourable results when followed diligently. However, even with excellent training and execution, maintaining oversight and ensuring compliance of this process becomes challenging in large organisations with numerous wards/substantial staff turnover. The Comfort Shield® Barrier Cream Cloths simplify this process by combining cleansing, protecting, and restoring products into one, reducing the number of steps, making it easier and more convenient for clinicians [25]. By prioritising quality, effectiveness and patient experience over initial expenditure, organisations can achieve better patient outcomes while optimising resource allocation in IAD management.

Another favourable finding was the reduction in underpads/bed protectors use, leading to a significant decrease in these costs. This finding is consistent with a study that found a cost reduction due to cessation of washable and disposable underpads in an initiative to reduce hospital-acquired pressure injuries [27]. Underpads and plastic sheets predispose a patient to skin breakdown by impairing the skin microclimate and increasing skin friction. Removing these minimises a patient's risk of skin breakdown. The reduction in plastic products would also equate to a decrease in environmental costs.

The impact of COVID-19 on higher acuity is evident in the data.

Patients in the post-intervention period had poorer health, longer LoS, were doubly incontinent and more likely to be discharged to nursing homes compared to patients in the pre-intervention period. Consequently, there was a greater number of staff attending incontinence care episodes and they spent more time per episode in the post-intervention period. Both changes were drivers for the higher cost of staff attendances for each episode. Despite this, the difference in mean total cost between the two periods was not significant as the cost reduction in products offset the increase in staff.

Changes in the type and number of products and staff time used to care for patients with incontinence/skin breakdowns in this study are indicative of the hospitals moving towards best practice [28]. IMBED utilised an implementation science framework [29] to positively affect acute health service delivery by improving clinician understanding of evidence-based approaches for incontinence skin breakdown [4], which involved developing and testing a knowledge instrument on IAD [30] and showing improvements in clinician knowledge [28]. Improvements in clinician knowledge could optimise the use of healthcare resources, delivering the right care in the right setting and at the right time, which are the incentives for embedding change [31]. The increase of only AU \$0.15 per episode demonstrates potential for efficiency gains through implementing IMBED. This modest change suggests that the hospitals were able to implement IMBED without incurring substantial expenses and thus have potential to sustain improvements in incontinence care and IAD prevention.

This study has strengths and limitations. One strength is that the study examined multiple costs (products and staff) and outcomes (LoS) from the health system standpoint. Another strength is that the type and number of healthcare resources used were collected at the micro-level [32] by firstly, compiling a list of all pertinent healthcare resources with clinicians/researchers and secondly, nurses/ROs collecting information on the various resources used for incontinence care episodes. This approach enabled assessment of resource utilisation and unit cost data to generate accurate cost estimates [33].

Three limitations of our study are noteworthy. Firstly, there were different patients in the pre-and post-cohorts which impacts the generalisability of the findings due to different patient acuity and characteristics, and secondly, data collection was for a random sample of incontinence care episodes. Lastly, and related in part to the aforementioned limitations, the HE study is not a CEA or CUA and thus does

**Table 6**  
Total costs per episode of care.

		All Records (AU\$) N = 9645	Pre-intervention (AU\$) N = 5821	Post-intervention (AU\$) N = 3824	Difference in AU\$ (p-value)
Skin cleansers	Mean	0.88	0.85	0.91	0.06 (0.25)
	Median	0.18	0.20	0.15	
	Range	0.00–28.82	0.00–17.25	0.00–28.82	
Prevention/treatment products	Mean	0.79	0.77	0.82	0.04 (0.12)
	Median	0.52	0.52	0.60	
	Range	0.00–10.99	0.00–10.99	00.00–9.87	
Other creams <sup>a</sup>	Mean	0.17	0.28	0.004	–0.28 (<0.001)
	Median	0.00	0.00	0.00	
	Range	0.00–5.99	0–5.99	0.00–2.78	
Pads	Mean	0.59	0.59	0.59	–0.002 (0.68)
	Median	0.64	0.64	0.64	
	Range	0.00–2.91	0.00–2.56	0.00–2.91	
Underpad/bed protectors <sup>a</sup>	Mean	0.11	0.15	0.04	–0.10 (<0.001)
	Median	0.00	0.00	0.00	
	Range	0.00–3.00	0.00–3.00	0.00–1.00	
<b>Total product costs<sup>a</sup></b>	Mean	2.53	2.64	2.35	–0.29 (<0.001)
	Median	1.61	1.52	1.65	
	Range	0.00–22.31	0.00–20.04	0.00–22.31	
Staff cost <sup>a</sup>	Mean	9.82	9.65	10.09	0.44 (0.001)
	Median	7.7	6.9	8.2	
	Range	0–102	0–101	0–103	
<b>Total cost per episode</b>	Mean	12.36	12.30	12.45	0.15 (0.344)
	Median	11.25	11.01	11.57	
	Range	0.45–107.86	0.45–107.89	0.54–103.68	

<sup>a</sup> Statistical t-tests showed statistically significant differences between pre- and post-intervention.

not report summary measures such as ICERs or quality adjusted life years (QALYs) gained. Rather, this study provides a detailed analysis of resource use and costs reporting differences in clinical measures between pre- and post-IMBED intervention cohorts including tests of significance, which are consistent with a CCA.

## 5. Conclusion

Mean total cost per incontinence care episode increased by only AU \$0.15 and was not statistically significant for the intervention, indicating hospitals could implement IMBED without incurring notable additional expenses. Importantly, use of less desirable creams and underpads/bed protection layers decreased, while use of more appropriate 3-in-1 barrier cream cloths increased. This shift in usage patterns, occurring with a minor cost increase, highlights the success of IMBED and its components as well as improvements in patient outcomes. Cost-effectiveness should be explored in terms of how IMBED effects not only resource usage (and costs) but also health outcomes and efficiency (such as calculating relevant ICERs or returns on investment) in an economic evaluation to determine more fully the value of IMBED from a health system/societal perspective. Nevertheless, healthcare policymakers/procurement departments should consider including IMBED as an alternative to standard care in statewide/national healthcare policies, given it has been shown to improve the provision of evidence-based incontinence care across diverse healthcare settings.

## Author contributions

The paper was conceptualised and designed by MC, MJB, FC, ML, SA and JC. The first draft of the paper was written by MC with sections of

the Methods and Results drawing on reports written by SA and JC who conducted the analysis of the cost and other outcomes data for the IMBED project. MC, MJB, FC and ML provided substantial intellectual inputs on these reports. MJB and ML made substantial contributions to the acquisition of data. SA and JC undertook the analysis of the cost and outcomes data. MC, MJB, FC, SA and ML made substantial contributions to interpretation of data and/or results. All authors made contributions to revising it critically for important intellectual content.

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## Conflicts of interest

Nil to declare for all authors.

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## Appendix

### Appendix Table 1

Type of incontinence by recruitment period

Type of incontinence	All episodes of care N = 9645 n (%)	Pre-intervention N = 5821 n (%)	Post-intervention N = 3824 n (%)	Difference between pre and post p-value
Urine	6076 (63.0)	3531 (60.7)	2545 (66.6)	<0.001 <sup>1</sup>
Faecal	1114 (11.6)	717 (12.3)	397 (10.4)	
Both	2030 (21.1)	1289 (22.1)	741 (19.4)	
Data missing	425 (4.4)	284 (4.9)	141 (3.7)	

<sup>1</sup>Chi<sup>2</sup> tests showed statistically significant differences between the pre- and post-intervention populations.

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