

Overcrowding in emergency departments: A review of strategies to decrease future challenges

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Emergency departments (EDs) are the most challenging ward with respect to patient delay. The goal of this study is to present strategies that have proven to reduce delay and overcrowding in EDs. In this review article, initial electronic database search resulted in a total of 1006 articles. Thirty articles were included after reviewing full texts. Inclusion criteria were assessments of real patient flows and implementing strategies inside the hospitals. In this study, we discussed strategies of team triage, point-of-care testing, ideal ED patient journey models, streaming, and fast track. Patients might be directed to different streaming channels depending on clinical status and required practitioners. The most comprehensive strategy is ideal ED patient journey models, in which ten interrelated substrategies are provided. ED leaders should apply strategies that provide a continuous care process without deeply depending on external services.

Key words: Emergency department, overcrowding, patient flow, patient journey, patient safety

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INTRODUCTION

Overcrowding in emergency departments (EDs) is a concerning global problem and has been identified as a national crisis in some countries.^[1,2] Overcrowding of EDs is defined as "the situation in which ED function is impeded primarily because of the excessive number of patients waiting to be seen, undergoing assessment and treatment, or waiting for departure comparing to the physical or staffing capacity of the ED."^[3] Patients' safety and privacy,^[4,5] timeliness of the services,^[4] and frustration among ED staff^[6] should be considered in the studies of overcrowding in EDs.

Imbalances between the capacity of the ED and the demand for patient triage, diagnostic images, laboratory tests, and specialty consultations affect the patient flow

in ED.^[7,8] In addition, some studies have identified the effect of high occupancy (above 90%) and access block as causes of adverse patient outcomes, treatment delays, high mortality rates (20%–30%), prolonged inpatient length of stay (LOS), and hospital readmission.^[9–11] The high occupancy of the ED can also be explained by the majority (50%–75%) of patients get admitted to the hospitals through ED.^[12]

To alleviate the problem of ED overcrowding, different solutions are proposed by researchers such as input-throughput-output conceptual model of ED crowding,^[13] increasing the resources, demand management, operation research,^[11] lean thinking,^[14] chest pain observation units,^[15] rapid assessment zones,^[16] and clinical decision units.^[17] Lean health-care thinking led many of the new strategies with redesigning the optimal pathways, contributing value steps, and deleting nonvalue steps.^[18] Four-hour target has been

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introduced by health authorities to decrease the LOS in ED.^[19,20] Despite previous efforts, limited scientific knowledge on how to improve patient flow in ED has achieved.^[1]

The objective of this review article is to present strategies with an important role in the improvement of patient flow, delay in services, and overcrowding of the EDs.

MATERIALS AND METHODS

In this review article, we performed a computerized database search to identify relevant articles. We searched for published and ready-to-publish articles in bibliographic databases, including ISI Web of Science, PubMed, Science Direct, Scopus, Wiley online library, Google Scholar, and other governmental, national, and international databases and websites. In addition, the literature search also involved a manual search of bibliographies of the identified papers and relevant information to meet the objectives of this study. An extensive search of keywords used in the search were "Emergency Department (ED)," "Overcrowding," "Triage," "Patient Acuity," "Hospital Emergency Services," "Emergency Room/Ward," "length of Stay (LOS)," "Patient Navigation," "ED Patient journey," "ED Patient Flow," "Ambulance diversion," "Emergency Outpatient Unit," and "Patient Safety." Table 1 provides details on the specific search terms and combinations. The selection of these terms

was made with the help of MeSH service in PubMed website databases.

Data extraction

Independent reviewers (FR and MHY) screened abstracts and titles for eligibility. When the reviewers felt that the abstract or title was potentially useful, full copies of the article were retrieved and considered for eligibility by both reviewers. When discrepancies occurred between reviewers, the reasons were identified, and a final decision was made based on a third reviewer (AH) agreement. STROBE scale was used to select the studies for this review.

Inclusion and exclusion criteria

For this review article, the literature limited to journal articles and governmental documents in English and Persian. The search included studies to 2016. The main reasons for exclusion were: (1) not assessing any real patient flow in EDs and (2) assessing patient flow outside the hospitals or specialized services of hospitals.

RESULTS

The initial electronic database search of the literature resulted in a total of 1006 articles [Figure 1]. Of these, 136 were selected as potential studies based on their titles and abstracts. After the complete article was read, however, only thirty of these actually fulfilled the inclusion criteria. One hundred and six papers were excluded after reading the complete article.

Key strategies in controlling overcrowding in EDs have been categorized in this study [Table 2]. Facilities can utilize each of them as follows:

Streaming in the patient journey

Predefined criteria for designing patients' flow after triage divide processes into different streams. The most typical streaming is called the fast track for handling patients with less serious symptoms.^[50]

Health-care processes before and after the ED visit are interrelated. Examples of processes before the ED are prehospital and primary care visit, and provision of hospital beds is an example of a process after the ED visit. Therefore, it is important to review and improve all the health-care-related processes during patient visit systematically. Moreover, it should be considered in studies and decision-makings that access to ED is an issue at a strategic government level, whereas throughput efficiencies are being addressed at a local operational level.^[51]

Strategies to manage throughput ED patient flow should focus on the following issues: Patient acuity levels, prolonged

Table 1: Result and keywords from each database

Database	Other Keywords	Results
ISI Web of Science	Patient flow, emergency care delivery, admission predictive tool, waiting times, ED under crowding, crowding measure, patient grouping, and prioritization	22
PubMed	Patient handoff, utilization of EDs, ED enlargement, triage processes, transfer of care, nonurgent visits redirection, fast track	334
Science direct	Capacity in EDs, emergency medicine, overcrowding strategies, overcrowding mitigation, complaints and violence in the ED	143
Scopus	Offload zone patient selection, patient transfer, ED referral, streamlined admission, overcrowding management, routes of admission in, ED treatment rooms assigning, capacity allocation in ED	427
Wiley online library	Patient disposition, clogging ED, access block, short-stay units in EDs, safe capacity in EDs, ED occupancy, emergency journey, delayed disposition, busy EDs	5
ISD	The length of stay, waiting time measurement	7
Google Scholar	Same as all the above keywords	68

EDs = Emergency departments

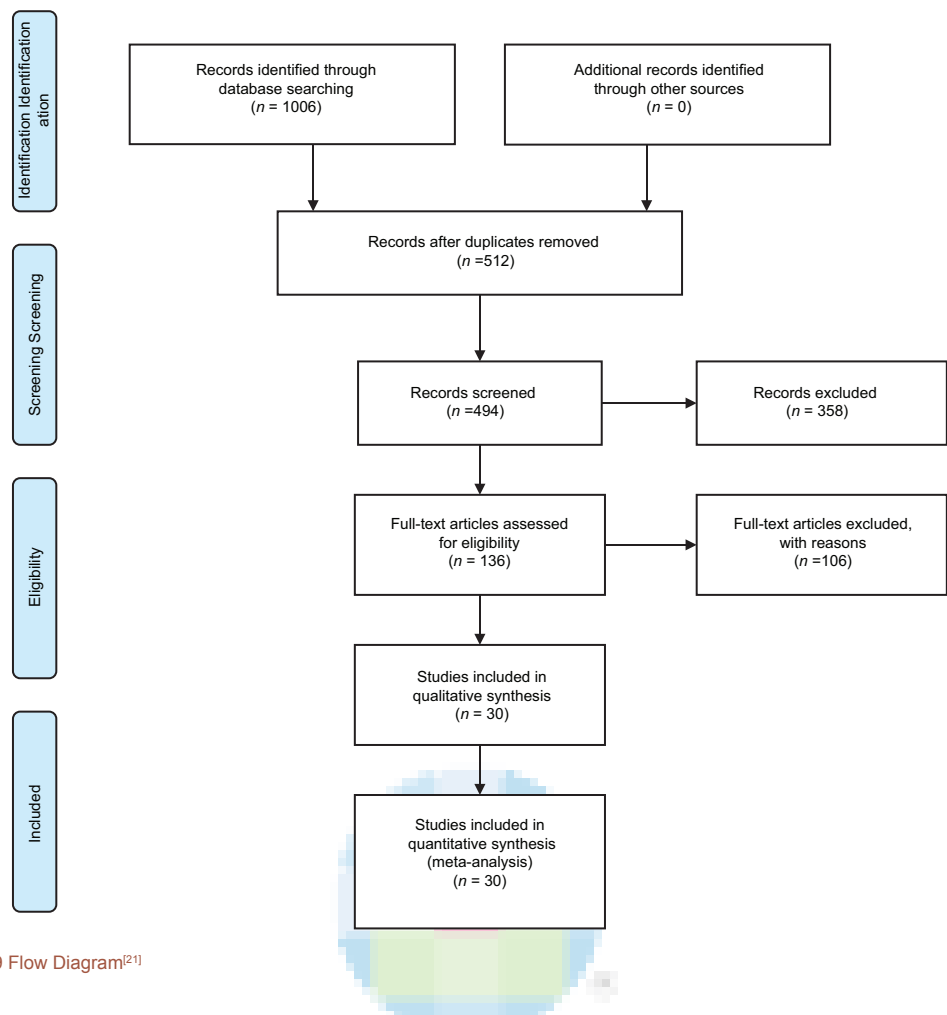


Figure 1: PRISMA 2009 Flow Diagram^[21]

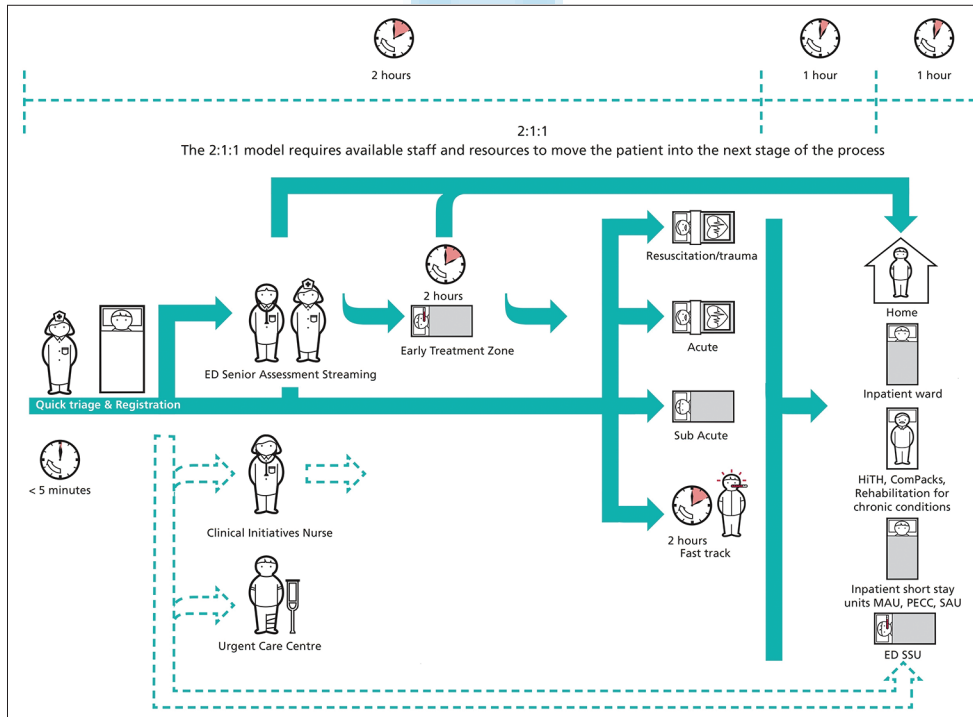


Figure 2: The ideal patient journey with streaming to models of care within emergency department and external to emergency department^[49]

Table 2: Description of strategies to overcome emergency department overcrowdings

Strategies	Patient characteristics	Responsible practitioners	Coverage	Advantages	Challenges
Streaming	For minor injuries, especially those patients discharged home ^[22]	ED clinicians	All patients	Reducing crowding Improve the efficiency Groups of patients co-located to discrete areas to provide care with resources according to patients' needs ^[23]	Streaming creates the potential for one stream to be under pressure with treatment delays while another is quiet ^[24] Misallocation of patients ^[25]
Fast track	Nonemergency patients with uncomplicated diseases ^[26,27]	Nurse practitioner and doctors ^[28]	10% and 30% of total patients are seen in the ED ^[29,30]	Reducing the total number of patients staying in the ED Improving patient satisfaction and patient safety Patients received high quality of care ^[28,31]	Usually more applicable during peak hours, i.e., not during nights ^[32]
Team triage	Most significant in complex situations	A team with administration of a senior physician/nurse, a nurse initially evaluates the patient (spot check) and a receptionist or a nurse assistant ^[24,33,34] / physician-MDRNSTAT ^{*,35,36]} / TLPs* role ^[37]	Not found	Increasing accuracy and efficiency in the initial process of patient evaluation ^[35] as all of the team members received the same information simultaneously, thereby allowing them to work in a more coordinated manner ^[38] Patient examinations and diagnostic measures would be initiated earlier ^[39] Reduce LOS* for low-acuity patients ^[40] Improving teamwork within hospitals ^[34]	Handling time per patient is essential to define the tasks of a team indirectly Team triage is not implementable if sick patients are waiting at the expense of minor injuries and for 24 h because of the insufficient resources ^[24]
POCT/ POC-US*	For high-risk patients suspected to have HIV or other dangerous communicable disease/ dyspnea patients whose laboratory, radiology and ultrasound tests were ordered by the ED ^[41-43]	POCT-trained nurses	About 30%-66% of all patients at an ED ^[8,44]	Improvement of nurses' ability to incorporate testing into their existing clinical care ^[45] Positive effects on LOS or waiting times ^[46,47]	Increased costs POCT effect only on patients discharged home, and no significant impact on patients admitted to hospital The limited impact can be expected if many patients need central laboratory analyses in addition to POC ^[48]
Ideal ED patient journey models (within EDs) ^[51]	Acute care of complex, nonambulatory, high-acuity patients Lower acuity, complex, nonambulatory patients Noncomplex, ambulatory patients	Early senior medical assessment Clinical initiatives nurse Clerical officer co-located with the triage nurse	Not found	Providing multiple MOC* options to assess and treat patients Allowing local health facilities have access to appropriate MOC depending on their ED Ensuring tasks are performed by the provider who can most efficiently perform the task Eliminating duplication of processes Reducing unproductive waiting periods	A direct referral to another provider for those patients who need care, but do not require emergency care Mental health Dental Sexual assault without injuries requiring ED management Early pregnancy assessment service Palliative care Aged care assessment and rehabilitation Specialist referral (rooms or direct to inpatient ward) Hospital in the home and postacute care services Outpatient's clinic referral Urgent care center Medical assessment unit Surgical assessment unit Postoperative review patients Drug and alcohol patients Fracture reviews

*MDRSTAT = Physician–nurse supplementary team at triage; MOC = Models of emergency care; TLPs = Triage liaison physicians' role;
POC-US = Point-of-care-ultrasonography; LOS = Length of stay; POCT = Point-of-care testing; EDs = Emergency departments

ED evaluations, inadequate inpatient bed capacity, shortage of staff, problems with access to on-call specialists, and the use of ED by those who have no alternative medical care, such as the uninsured patients.^[52]

Fast track

Many hospitals have developed their own priority for providing fast track care, such as superficial wounds, nonsevere allergic reactions, fractures and distortions of small joints and bones, dog and cat bites, and minor burns.^[26]

Team triage

Physician–nurse supplementary triage assistance team (MDRNSTAT) is considered to be more cost-effective than team triage during time periods with higher patient volume.^[35] On the other hand, triage liaison physicians' (TLPs) role also proposes throughput factors contributed to ED overcrowding. The TLP's role is to work with triage staff to expedite the care of patients based on their medical needs, especially for those with unpredictable waiting times.^[37,53]

Development of triage systems

Medical Emergency Triage and Treatment System protocol in Sweden determines priority level based on the combination of vital parameters, symptoms, and signs, which are closely related to hospital LOS.^[54] Other common models in Sweden are the Adaptive Process Triage or nurse/emergency physician triage and the Manchester Triage Scale or nurse/junior triage.^[55] The reason for applying these new systems is an improvement in patient flow and increasing patient safety.^[50] Kelen *et al.* introduced "Reverse Triage" as a system for safe early discharge of hospital inpatients to create additional inpatient capacity.^[56] Telephone triage system is also a way of after-hours care in EDs, ambulance, and general practice services.^[57]

Point-of-care testing

In theory, similar to lean thinking strategy, this tool eliminates some of the most problematic steps in the testing process, such as specimen transport and result distribution.^[58] The Centers for Disease Control and Prevention introduced strategies to make HIV testing a routine part of health care by promoting simplified procedures to make testing more practical.^[43] To reduce wait time of laboratory testing, the following interventions have been proposed: early ordering, predefined test panels based on symptoms, faster transportation to the laboratory, and faster reporting systems and point-of-care-testing (POCT).^[50] Introducing POCT to the ED has significantly decreased turnaround time for the laboratory analyses which involve moving analytical instruments to the ED.^[59]

Nurse-requested X-ray

This diagnostic procedure is another time-consuming process in the ED. To overcome waiting time, nurse-requested X-ray has piloted in some hospitals.^[50]

Ideal emergency department patient journey models

The emphasis of the care is to stream patients into the most appropriate care model as early as possible. A set of possible [Figure 2] ED processes developed by New South Wales are summarized below:

- Triage and registration, clinical initiatives nurse, resuscitation (including trauma), acute care, early ED senior assessment and streaming, early treatment zone, fast track, subacute, 2:1:1, and ED short-stay units [Figure 1]
- This strategy provides an overview of models of care outside the ED that can support patient flow and provide timely access to acute care services: Medical assessment unit, surgical assessment unit, a hospital in the home, and psychiatric emergency care center services
- This strategy provides an overview of community models of care that provide access to unscheduled ambulatory care: Urgent care center, health direct Australia advice line, connecting care, and after-hours general practitioner clinic.

DISCUSSION

We need to consider the various aspects of overcrowding to overcome the emerging challenges. Overcrowding is associated with increased mortality, misplacing patients in an incorrect ward, delays in the initiation of critical cares (such as the administration of antibiotics in sepsis), longer physician waiting times, access block, decreased patient safety, decreased inpatient bed capacity due to high inpatient bed occupancy, and inefficient inpatient flow within the ED because of unnecessary peaks in demand for inpatient beds for elective surgery.^[11,60-63]

Several interventions have been proposed to alleviate ED overcrowding in all the three levels of input, throughput, and output: Input (e.g., ambulance diversion), through-put (e.g., rapid assessment zones/pods, and clinical decision units), and output (e.g., full-capacity protocols, bed managers). The last two interventions will improve output for admitted patients, but these are not completely under the control of ED leaders and require system-wide interventions.^[53] However, it is important to know that delay in patient flow during throughput phase has a significant influence on overcrowding. We considered contingency strategies during throughput phase and discussed them in the following section.

The main effect of team triage strategy would be fewer patients leaving without being visited by a practitioner.

Another positive effect is streaming patients more rapidly.^[50] Wang and Vikram's research has shown that presence of a family medicine resident physician in ED is associated with reduced waiting time and patients leaving without being seen.^[64] Hence, the team triage strategy through the participation of a physician as the leader could be one of the benchmarks.

Another effective intervention that has been appeared to be helpful in reducing the LOS, especially in injury and/or suspected fracture cases requiring radiography, is triage nurse ordering.^[65]

There are different types of alternative short-stay units including fast track, ambulatory areas, see and treat services, minor injury units, and rapid intervention and treatment zones. Numerous studies have shown that these units can effectively reduce mortality, the LOS, and access block, as well as improve staff and patient satisfaction.^[51]

Among strategies discussed in this study, fast track is proven to have scientific evidence as many studies illustrated that fast track not negatively effects on treatments of patients with the more severe emergency condition. In addition, fast track would likely have financial benefits and higher patient satisfaction (e.g., shorter waiting time, shorter LOS, and fewer patients leaving without being seen). However, further studies are required to evaluate ethics and patient safety of these interventions. The presence of a senior physician, a junior doctor, or nurse practitioner to manage fast track has been recommended in previous studies. Patient selection is another issue for the fast track as patients should be managed without too many diagnostic procedures, for example, laboratory tests and diagnostic images. Moreover, the fast track should be separated from areas where acute patients with severe medical condition are managed.^[66-68]

For paramedical services, laboratory examination of patients is another challenge in EDs. Directing patients to the laboratory testing stream is complex and time-consuming.^[69] This process has different steps, such as ordering, sampling, marking, transportation, analysis, reporting of results, interpretations, and informing patients.^[58] The laboratory testing stream increases the LOS in the ED about 80 min.^[70] The range of tests also effects on waiting time and LOS.^[62] Technical advancements expand the range of tests, which can decrease the LOS in the future.^[71] In addition, it is necessary to consider and evaluate the prerequisites for quality management and reliability of every method. Low precision affects patient safety and leads to adverse events.^[58]

There are other strategies that do not meet our eligibility criteria such as implementing outside the hospital or having

simulation-based concepts. We will discuss some of the most widely used strategies.

Alternative care facilities

This strategy has been applied increasingly in many countries. Uncomplicated patients are referred to primary health-care centers outside the hospital such as ambulatory care facilities,^[72] considering surge capacity as a contingency approach that will improve accessibility, reduce waiting time, lower costs, and improve patient outcome, staff satisfaction, and customer experience.^[52]

Overcrowding hazard scale model

This model includes statistics variables that are used to anticipate hazard ratio in future: Age (more than 50 years), transport (ambulance vs. nonambulance), diagnosis (illness vs. injury), Australasian Triage Scale Urgency Category 1 (resuscitation vs. less-urgent categories of 3, 4, and 5), Australasian Triage Scale Category 2 (emergency vs. less-urgent categories of 3, 4, and 5), overcrowding hazard scale (multiplying the hospital occupancy score and the ED access block occupancy score), and referral practitioners (physician vs. nonmedical). This strategy can be used to monitor the overcrowding hazards in actual time.^[9] Simulation of patient flow in ED is helpful to anticipate the near-future operating conditions with variables such as waiting count, waiting time, occupancy level, the LOS, boarding count, boarding time, and ambulance diversion.^[73]

Strategies for patient flow after ED should direct limitations as follows: lack beds, insufficient access to inpatient beds, inflexible paper-based systems, isolation precautions, cleaning delays, over-reliance on Intensive Care Units, high bed dependency, and inefficient diagnostics with delays in discharging hospitalized patients.^[13] In this study, we focus more on input and throughput strategies.

Emergency medicine ward

Populations under coverage of these facilities in a region are provided custom-made services. The focus is on patients who can be managed within 24–48 h of in-patient stay. Services are delivered interdepartmentally through interdisciplinary collaboration and consultation. After the rapid assessment, patients are referred to the next level of care such as community nurse service or a geriatric team. Emergency specialists round wards and perform four to six rounds per day.^[74]

It is important to consider the synergetic effects of all the interventions described in this review as the effect of an intervention is not isolated, especially because of interference with organizational issues. Local context, organizational factors, and cost-effectiveness analysis

of ED models necessitate additional methodological approaches with a sharper focus on outcomes of quality, patient and staff satisfaction, and economic and ethical issues.^[51] Strategies for managing throughput ED patient flow should focus on the following issues: patient acuity levels, prolonged ED evaluations, inadequate inpatient bed capacity, a severe shortage of staff, problems with access to on-call specialists, and the use of ED by those with no other alternative to medical care, such as the uninsured.^[52] Consequently, further studies must employ a systematic approach to evaluating the most likely way to success. Lean thinking, in which continuous improvement in all parts of processes is considered, would be helpful in this field of study.

Limitation

Only articles in English and Persian were included. Information bias is possible to occur in the field of misclassification of main concepts. In addition, selection bias could be considered in the field of publication bias within studies, especially nonaccessible governmental reports and books.

CONCLUSION

Overcrowding in hospitals is a complex phenomenon. The quality of services in EDs depends on coordinated efforts between emergency physicians, on-call specialists, emergency nurses, other health professionals, laboratory, diagnostic imaging services, and inpatient units. If any of these interdependent components disrupts the processes, health care would counter with difficulty. ED leaders can control some of these components. However, many components are controlled by stakeholders outside the ED whose priority may not be optimizing patient care in the ED. Thus, the ED may experience poor communication with laboratory and imaging services, restricted access to inpatient beds. ED leaders must focus on discussion meeting with institutional executives, internal and external stakeholders, and public policymakers to implement initiatives to ease ED crowding.^[75]

In addition, economic incentives of high occupancy, aging population phenomenon in developed countries, and not predicting emergency demands to optimize capacity may cause overcrowding. Solutions could be a realignment of financial incentives, considering misuse and overuse of health services, and improved chronic disease management to reduce hospital bed demand.^[76-78]

Although various models of care have been invented these days, understanding how and which models could be implemented in which organization requires further

researches. Keeping challenges and advantages of each model help us choose the correct way.

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Conflicts of interest

There are no conflicts of interest.

AUTHORS' CONTRIBUTION

FR and MHY contributed in the conception of the work, conducting the study, revising the draft, approval of the final version of the manuscript, and agreed for all aspects of the work. NT and AH contributed in the conception of the work, drafting and revising the draft, approval of the final version of the manuscript, and agreed for all aspects of the work.

REFERENCES

1. Eitel DR, Rudkin SE, Malvey MA, Killeen JP, Pines JM. Improving service quality by understanding emergency department flow: A white paper and position statement prepared for the American Academy of Emergency Medicine. *J Emerg Med* 2010;38:70-9.
2. Institute of Medicine Committee on the Future of Emergency Care in the U.S. Health System. The future of emergency care in the United States health system. *Ann Emerg Med* 2006;48:115-20.
3. Statement on Emergency Department overcrowding. Australasian college for emergency medicine 2011; S57: Jul-16.
4. Bernstein SL, D'Onofrio G. Public health in the emergency department: Academic emergency medicine consensus conference executive summary. *Acad Emerg Med* 2009;16:1037-9.
5. Moskop JC, Sklar DP, Geiderman JM, Schears RM, Bookman KJ. Emergency department crowding, part 1 – Concept, causes, and moral consequences. *Ann Emerg Med* 2009;53:605-11.
6. Derlet RW, Richards JR. Overcrowding in the nation's emergency departments: Complex causes and disturbing effects. *Ann Emerg Med* 2000;35:63-8.
7. Walley P. Designing the accident and emergency system: Lessons from manufacturing. *Emerg Med J* 2003;20:126-30.
8. Yoon P, Steiner I, Reinhardt G. Analysis of factors influencing length of stay in the emergency department. *CJEM* 2003;5:155-61.
9. Sprivilis PC, Da Silva JA, Jacobs IG, Frazer AR, Jelinek GA. The association between hospital overcrowding and mortality among patients admitted via Western Australian emergency departments. *Med J Aust* 2006;184:208-12.
10. Forero R, Hillman K. Access Block and Overcrowding: A Literature Review. The Simpson Centre-UNSW (prepared for ACEM); 2008. p. 79.
11. Hoot NR, Aronsky D. Systematic review of emergency department crowding: Causes, effects, and solutions. *Ann Emerg Med* 2008;52:126-36.
12. Dawson H, Weerasooriya J, Webster G. Hospital admissions via the emergency department: Implications for planning and patient flow. *Healthc Q* 2008;11:20-2.
13. Asplin BR, Magid DJ, Rhodes KV, Solberg LI, Lurie N, Camargo CA Jr. A conceptual model of emergency department crowding. *Ann Emerg Med* 2003;42:173-80.
14. Holden RJ. Lean Thinking in emergency departments: A critical

- review. *Ann Emerg Med* 2011;57:265-78.
15. Martinez E, Reilly BM, Evans AT, Roberts RR. The observation unit: A new interface between inpatient and outpatient care. *Am J Med* 2001;110:274-7.
16. Bullard MJ, Villa-Roel C, Guo X, Holroyd BR, Innes G, Schull MJ, *et al.* The role of a rapid assessment zone/pod on reducing overcrowding in emergency departments: A systematic review. *Emerg Med J* 2012;29:372-8.
17. Roberts MV, Baird W, Kerr P, O'Reilly S. Can an emergency department-based clinical decision unit successfully utilize alternatives to emergency hospitalization? *Eur J Emerg Med* 2010;17:89-96.
18. George M, Rowlands D, Price M, Maxey J. Value stream mapping and process flow tools. *Lean Six Sigma Pocket Toolbook*. New York: McGraw Hill; 2005.
19. Horwitz LI, Green J, Bradley EH. US emergency department performance on wait time and length of visit. *Ann Emerg Med* 2010;55:133-41.
20. Banerjee A, Mbamalu D, Hinchley G. The impact of process re-engineering on patient throughput in emergency departments in the UK. *Int J Emerg Med* 2008;1:189-92.
21. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Ann Intern Med* 2009;151:264-9, W64.
22. Grouse AI, Bishop RO, Gerlach L, de Villecourt TL, Mallows JL. A stream for complex, ambulant patients reduces crowding in an emergency department. *Emerg Med Australas* 2014;26:164-9.
23. Saghaian S, Hopp WJ, van Oyen MP, Desmond JS, Kronick SL. Patient streaming as a mechanism for improving responsiveness in emergency departments. *Oper Res* 2012;60:1080-97.
24. Subash F, Dunn F, McNicholl B, Marlow J. Team triage improves emergency department efficiency. *Emerg Med J* 2004;21:542-4.
25. Kim SW, Horwood C, Li JY, Hakendorf PH, Teubner DJ, Thompson CH. Impact of the emergency department streaming decision on patients' outcomes. *Intern Med J* 2015;45:1241-7.
26. Karpel M, Williams M. Developing a FAST TRACK program. *J Ambul Care Mark* 1988;2:35-48.
27. van Donk P, Tanti ER, Porter JE. Triage and treat model of care: Effective management of minor injuries in the emergency department. *Collegian*. [In press]
28. Dinh M, Walker A, Parameswaran A, Enright N. Evaluating the quality of care delivered by an emergency department fast track unit with both nurse practitioners and doctors. *Australas Emerg Nurs J* 2012;15:188-94.
29. O'Brien D, Williams A, Blondell K, Jelinek GA. Impact of streaming "fast track" emergency department patients. *Aust Health Rev* 2006;30:525-32.
30. Ardagh MW, Wells JE, Cooper K, Lyons R, Patterson R, O'Donovan P. Effect of a rapid assessment clinic on the waiting time to be seen by a doctor and the time spent in the department, for patients presenting to an urban emergency department: A controlled prospective trial. *N Z Med J* 2002;115:U28.
31. Roche KT, editor. Improving patient safety by maximizing fast-track benefits in the emergency department – A queuing network approach. *IIE Annual Conference Proceedings*. US, Arizona: Institute of Industrial Engineers; 2007.
32. Rogers T, Ross N, Spooner D. Evaluation of a "See and Treat" pilot study introduced to an emergency department. *Accid Emerg Nurs* 2004;12:24-7.
33. Travers JP, Lee FC. Avoiding prolonged waiting time during busy periods in the emergency department: Is there a role for the senior emergency physician in triage? *Eur J Emerg Med* 2006;13:342-8.
34. Burström L, Letterstål A, Engström ML, Berglund A, Enlund M. The patient safety culture as perceived by staff at two different emergency departments before and after introducing a flow-oriented working model with team triage and lean principles: A repeated cross-sectional study. *BMC Health Serv Res* 2014;14:296.
35. Cheng I, Castren M, Kiss A, Zwarenstein M, Brommels M, Mittmann N. Cost-effectiveness of a physician-nurse supplementary triage assessment team at an academic tertiary care emergency department. *CJEM* 2016;18:191-204.
36. Cheng I, Lee J, Mittmann N, Tyberg J, Ramagnano S, Kiss A, *et al.* Implementing wait-time reductions under Ontario government benchmarks (Pay-for-Results): A cluster randomized trial of the effect of a physician-nurse supplementary triage assistance team (MDRNSTAT) on emergency department patient wait times. *BMC Emerg Med* 2013;13:17.
37. Holroyd BR, Bullard MJ, Latoszek K, Gordon D, Allen S, Tam S, *et al.* Impact of a triage liaison physician on emergency department overcrowding and throughput: A randomized controlled trial. *Acad Emerg Med* 2007;14:702-8.
38. Burström L, Engström ML, Castrén M, Wiklund T, Enlund M. Improved quality and efficiency after the introduction of physician-led team triage in an emergency department. *Ups J Med Sci* 2016;121:38-44.
39. White BA, Brown DF, Sinclair J, Chang Y, Carignan S, McIntyre J, *et al.* Supplemented triage and rapid treatment (START) improves performance measures in the emergency department. *J Emerg Med* 2012;42:322-8.
40. Arbune A, Wackerbarth S, Allison P, Conigliaro J. Improvement through small cycles of change: Lessons from an academic medical center emergency department. *J Healthc Qual* 2015;0:1-11.
41. Bourcier JE, Paquet J, Seinger M, Gallard E, Redonnet JP, Cheddadi F, *et al.* Performance comparison of lung ultrasound and chest X-ray for the diagnosis of pneumonia in the ED. *Am J Emerg Med* 2014;32:115-8.
42. Pirozzi C, Numis FG, Pagano A, Melillo P, Copetti R, Schiraldi F. Immediate versus delayed integrated point-of-care-ultrasonography to manage acute dyspnea in the emergency department. *Crit Ultrasound J* 2014;6:5.
43. Centers for Disease Control and Prevention (CDC). Advancing HIV prevention: New strategies for a changing epidemic – United States, 2003. *MMWR Morb Mortal Wkly Rep* 2003;52:329-32.
44. Kankaanpää M, Raitakari M, Muukkonen L, Gustafsson S, Heitto M, Palomäki A, *et al.* Use of point-of-care testing and early assessment model reduces length of stay for ambulatory patients in an emergency department. *Scand J Trauma Resusc Emerg Med* 2016;24:125.
45. White DA, Scribner AN, Schulden JD, Branson BM, Heffelfinger JD. Results of a rapid HIV screening and diagnostic testing program in an urban emergency department. *Ann Emerg Med* 2009;54:56-64.
46. Asha SE, Chan AC, Walter E, Kelly PJ, Morton RL, Ajami A, *et al.* Impact from point-of-care devices on emergency department patient processing times compared with central laboratory testing of blood samples: A randomised controlled trial and cost-effectiveness analysis. *Emerg Med J* 2014;31:714-9.
47. Lee EJ, Shin SD, Song KJ, Kim SC, Cho JS, Lee SC, *et al.* A point-of-care chemistry test for reduction of turnaround and clinical decision time. *Am J Emerg Med* 2011;29:489-95.
48. Parvin CA, Lo SF, Deuser SM, Weaver LG, Lewis LM, Scott MG. Impact of point-of-care testing on patients' length of stay in a large emergency department. *Clin Chem* 1996;42:711-7.
49. NSWMO, editor. Emergency department models of care. In: *Health. North Sydney, New South Wales: Emergency Care Institute*; 2012.
50. Oredsson S, Jonsson H, Rognes J, Lind L, Göransson KE, Ehrenberg A, *et al.* A systematic review of triage-related

- interventions to improve patient flow in emergency departments. *Scand J Trauma Resusc Emerg Med* 2011;19:43.
51. Wylie K, Crilly J, Toloo GS, FitzGerald G, Burke J, Williams G, *et al.* Review article: Emergency department models of care in the context of care quality and cost: A systematic review. *Emerg Med Australas* 2015;27:95-101.
52. Hall R. *Patient Flow: Reducing Delay in Healthcare Delivery*. US, Rochester: Springer Science and Business Media; 2013.
53. Rowe BH, Guo X, Villa-Roel C, Schull M, Holroyd B, Bullard M, *et al.* The role of triage liaison physicians on mitigating overcrowding in emergency departments: A systematic review. *Acad Emerg Med* 2011;18:111-20.
54. Widgren BR, Jourak M. Medical emergency triage and treatment system (METTS): A new protocol in primary triage and secondary priority decision in emergency medicine. *J Emerg Med* 2011;40:623-8.
55. Burström L, Nordberg M, Ornung G, Castrén M, Wiklund T, Engström ML, *et al.* Physician-led team triage based on lean principles may be superior for efficiency and quality? A comparison of three emergency departments with different triage models. *Scand J Trauma Resusc Emerg Med* 2012;20:57.
56. Kelen GD, Kraus CK, McCarthy ML, Bass E, Hsu EB, Li G, *et al.* Inpatient disposition classification for the creation of hospital surge capacity: A multiphase study. *Lancet* 2006;368:1984-90.
57. Fry MM. A systematic review of the impact of after hours care models on emergency departments, ambulance and general practice services. *Australas Emerg Nurs J* 2011;14:217-25.
58. Plebani M. Does POCT reduce the risk of error in laboratory testing? *Clin Chim Acta* 2009;404:59-64.
59. Schimke I. Quality and timeliness in medical laboratory testing. *Anal Bioanal Chem* 2009;393:1499-504.
60. Goulding L, Adamson J, Watt I, Wright J. Patient safety in patients who occupy beds on clinically inappropriate wards: A qualitative interview study with NHS staff. *BMJ Qual Saf* 2012;21:218-24.
61. Wu D, Zhou X, Ye L, Gan J, Zhang M. Emergency department crowding and the performance of damage control resuscitation in major trauma patients with hemorrhagic shock. *Acad Emerg Med* 2015;22:915-21.
62. Bellow AA Jr., Gillespie GL. The evolution of ED crowding. *J Emerg Nurs* 2014;40:153-60.
63. Schull MJ, Szalai JP, Schwartz B, Redelmeier DA. Emergency department overcrowding following systematic hospital restructuring: Trends at twenty hospitals over ten years. *Acad Emerg Med* 2001;8:1037-43.
64. Xi W, Dalal V. Impact of family medicine resident physicians on emergency department wait times and patients leaving without being seen. *CJEM* 2015;17:475-83.
65. Rowe BH, Villa-Roel C, Guo X, Bullard MJ, Ospina M, Vandermeer B, *et al.* The role of triage nurse ordering on mitigating overcrowding in emergency departments: A systematic review. *Acad Emerg Med* 2011;18:1349-57.
66. Sanchez M, Smally AJ, Grant RJ, Jacobs LM. Effects of a fast-track area on emergency department performance. *J Emerg Med* 2006;31:117-20.
67. Combs S, Chapman R, Bushby A. Evaluation of fast track. *Accid Emerg Nurs* 2007;15:40-7.
68. Rodi SW, Grau MV, Orsini CM. Evaluation of a fast track unit: Alignment of resources and demand results in improved satisfaction and decreased length of stay for emergency department patients. *Qual Manag Health Care* 2006;15:163-70.
69. Storrow AB, Zhou C, Gaddis G, Han JH, Miller K, Klubert D, *et al.* Decreasing lab turnaround time improves emergency department throughput and decreases emergency medical services diversion: A simulation model. *Acad Emerg Med* 2008;15:1130-5.
70. Askenasi R, Lheureux P, Gillet J. Influence of tests on patient time in the emergency department. *Reanim Intensive care Med* 1989;5:201-2.
71. Lippa PB, Müller C, Schlichtiger A, Schlebusch H. Point-of-care testing (POCT): Current techniques and future perspectives. *Trends Anal Chem* 2011;30:887-98.
72. Chan CL, Lin W, Yang NP, Huang HT. The association between the availability of ambulatory care and non-emergency treatment in emergency medicine departments: A comprehensive and nationwide validation. *Health Policy* 2013;110:271-9.
73. Hoot NR, LeBlanc LJ, Jones I, Levin SR, Zhou C, Gadd CS, *et al.* Forecasting emergency department crowding: A discrete event simulation. *Ann Emerg Med* 2008;52:116-25.
74. Authority H, editor. *Clinical Services Plan for the New Territories East Cluster. Emergency Medicine Ward Operation Manual*. Hong Kong: AHNH, A and E Department; 2008.
75. Moskop JC, Sklar DP, Geiderman JM, Schears RM, Bookman KJ. Emergency department crowding, part 2 – Barriers to reform and strategies to overcome them. *Ann Emerg Med* 2009;53:612-7.
76. Kuntz L, Mennicken R, Scholtes S. Stress on the ward: Evidence of safety tipping points in hospitals. *Manage Sci* 2014;61:754-71.
77. Muller SW, Szczesny A, Ernst P. Value Chain, Quality-, and Cost Management in High Cost Areas in Response to Changing Economic Incentives-Evidence From a German Hospital. *Chris, Value Chain, Quality-, and Cost Management in High Cost Areas in Response to Changing Economic Incentives-Evidence From a German Hospital* (01 August, 2014); 2014.
78. Claret PG, Bobbia X, Jonquet O, Bousquet J, de La Coussaye JE. Integrated chronic disease management to avoid emergency departments: The MACVIA-LR® approach. *Intern Emerg Med* 2014;9:875-8.