

Emergency Department crowding and hospital bed shortage: is Lean a smart answer?

A systematic review

S. BUCCI¹, A.G. DE BELVIS¹, S. MARVENTANO², A.C. DE LEVA¹,
M. TANZARIELLO¹, M.L. SPECCHIA¹, W. RICCIARDI¹, F. FRANCESCHI³

¹Institute of Public Health, Hygiene Section, Catholic University of the Sacred Heart, School of Medicine, Rome, Italy

²Department "G.F. Ingrassia", Section of Hygiene and Public Health, University of Catania, Catania, Italy

³Department of Emergency, Internal Medicine Institute, Catholic University of the Sacred Heart, Rome, Italy

Abstract. – **OBJECTIVE:** Emergency Departments (EDs) worldwide face the challenges of crowding, waiting times, and cost containment. This review aims to provide a synthesis of the current literature focused on how Lean Thinking Principles and tools can be applied in an ED to address overcrowding and hospital admissions.

MATERIALS AND METHODS: Primary studies showing Lean interventions and implementation in ED visits, not requiring additional resources measuring specific outcomes (i.e. length of stay, patient volume, patient satisfaction, waiting times for the first visit, waiting times for diagnostic results, left without being seen) were selected. PubMed, Scopus, CINAHL, EconLit, NHS Economic Evaluation Database, Business Sources Complete, and Health Technology Assessment were used to conduct searches. Full-text articles of all potentially relevant publications were reviewed for eligibility. Discrepancies were resolved through discussion by all reviewers. Quality assessment and critical appraisal of selected studies were also evaluated by applying the Quality Improvement Minimum Quality Criteria Set.

RESULTS: Nine before-and-after studies met these eligibility criteria. Management of patient flow was the main intervention. Almost all studies showed EDs performance improvement: increased patient volume, decreased length of stay and number of patients left without being seen, reduced costs, and increased patient satisfaction. Only one case reported worse results after Lean intervention implementation.

CONCLUSIONS: Though Lean Principles have been used in healthcare for many years conclusion of their effects could still not be drawn. Surely, human-centered approach, top management support, work standardization, resources allocation and adaptation to the local

context seem to be crucial for success. Furthermore, higher quality studies are needed: specific research design, appropriate statistical tests and outcome measures are needed. Before large-scale implementation, further studies are needed to evaluate the true ability of Lean interventions to improve healthcare delivery.

Key Words:

Emergency care, Lean thinking, LOS, Hospital admission.

Introduction

Emergency Departments (EDs) worldwide face challenges of crowding, cost containment, and excessive waiting times^{1,2}. These issues represent larger problems in developed countries, resulting in disruption and inefficiencies to elective health care, patient discomfort, and higher in-hospital length of stay (LOS)^{3,4}. Also, emergency admissions entail higher costs for hospitals and health care systems. In England, in 2009/10, the National Health System estimated the cost of inpatient hospital admissions at £20.5 billion, of which emergency admissions alone contributed £11 billion⁵. The Institute of Medicine's Committee on the Future of Emergency care in the United States identifies improving EDs efficiency as a priority in hospitals⁶.

Solving EDs problems requires a revision of the entire process of EDs care and needs integration and collaboration of all healthcare professionals involved within all organizational levels. While it is well known that acute hospitals have

to set aside a defined number of beds for emergency admission, the optimal organization of unplanned admission to hospitals and the effective and efficient management of admitted patients flow in EDs is still uncertain. Although many external causes for EDs inefficiencies exist (i.e. social or financial) the internal organization of EDs also contributes to these inefficiencies⁷.

During the last decades, many healthcare organizations worldwide began adopting approaches such as Lean Thinking (Lean) to integrate better health care delivery. Lean is a set of business operating principles developed by Toyota Motor Corporation in 1950s⁸. Lean is considered a quality improvement method⁹. The key element in Lean is waste elimination through the identification of non-value-added activities, such as wasteful steps that don't give any value to the patient in terms of care (e.g. waiting times). This organizational philosophy emphasizes the identification of the root cause of a delay or problem with a bottom-up approach, starting from the workers and workplaces to understand the issues. Indeed, the starting point in a Lean re-engineering project is not a potential solution, but the development of a detailed understanding of how a complex process is actually performed. That is accomplished by designing a detailed map of the process (Value Stream Map – VSM) useful in identifying waste and bottlenecks, allowing the elimination of the non-value-added steps¹⁰⁻¹². In the case of an ED these wastes include: queuing, waiting for a provider evaluation or a laboratory result to come back, or being transported to x-ray¹³.

Since 2005, Lean has been used to face departmental problems in hospitals all over the world in order to improve the performance of care delivery and the efficiency of processes^{12,14-17}. This approach, as example, could include new diagnostic algorithms¹⁸ or diagnostic biomarkers¹⁹, that besides being cost-effective interventions, improve patients' outcomes. According to the Institute for Healthcare Improvement (IHI), the use of the Lean approach in only 2 years at Virginia Mason Medical Center led to improvements in lead time (65%), space (41%), setup time (82%), productivity (36% redeployed to other open positions) and inventory (53%)²⁰.

Supporting IHI's view, the literature shows how Lean has been applied to health organizations, above all in hospitals, and in particular in EDs, that seem to be pioneer departments in Lean implementation^{7,10,13,21-38}.

This systematic review aims to provide an exhaustive summary of current literature focused on how Lean principles and tools, applied in an ED, can solve the problem of overcrowding and facilitate the process of hospital admission.

Materials and Methods

Eligibility Criteria

This systematic review was conducted and reported in accordance with recommendations from the Cochrane handbook for Systematic Reviews of Interventions and the PRISMA Statement³⁹. We considered publications eligible for review if they met 5 criteria: (1) primary studies; (2) recruitment (everyday crowding); (3) intervention (application of Lean principles and tools in EDs); (4) outcome (i.e. LOS, patient volume, patient satisfaction, waiting times for first visit, waiting times for diagnostic results and left without being seen – LWBS rate); (5) no additional resources used (i.e. no extra nursing or medical staff, no structural changes). This last criterion allows the inclusion of only studies that measure outcomes after changing processes, in order to highlight only the results of Lean implementation and try to decrease heterogeneity. In fact, no statistical test is able to disambiguate effects of several changes applied simultaneously.

Search Strategy

The search was conducted independently by two reviewers (SM and ACDL) in the following electronic databases: PubMed, Scopus, CINAHL, EconLit, NHS Economic Evaluation Database, Business Sources Complete, Health Technology Assessment, without any limits on time or language in order to consider the whole existing body of literature. Each database was explored with the same combination of subject headings and text words. The primary search was conducted using the following algorithm: “integrated care” OR “continuity care” OR “primary care” AND “efficiency” OR “organizational” OR “length of stay” AND “lean thinking” OR “Toyota” AND “patient admission” OR “patient flow” OR “access block” AND “emergency service” OR “emergency department”. References lists of included manuscripts were also examined to find any additional study not previously identified.

Study Selection

All titles and abstracts of identified publications were screened according to the predeter-

mined inclusion and exclusion criteria. All publications considered potentially relevant were retained and the full-text articles were reviewed for eligibility. Disagreements were resolved through discussion to reach a final consensus by all the reviewers.

Quality Assessment

To assess methodological quality of selected studies, we applied a 5-level tools^{40,41} with some adaptation, as made in a previous review². Quality level 1 included prospective studies that aimed at assessing a clearly defined outcome measure with a random or consecutive sample size that was large enough to achieve narrow confidence intervals and diverse enough to suggest generalization of the findings. Quality level 2 included prospective studies that were more limited in terms of sample size or generalization. Quality level 3 included retrospective studies that otherwise would have satisfied the criteria for quality level 1 or 2. Quality level 4 included studies that sampled by convenience or other techniques that were prone to introduce bias. Quality level 5 included studies that lacked clearly defined or validated outcome measures. Quality assessment was performed by SM and AGdB, and disagreements were resolved by discussion.

Furthermore, we tested the Quality Improvement Minimum Quality Criteria Set (QI-MQCS) for the critical appraisal of included studies. QI-MQCS is a new tool, specific for quality improvement studies assessment, composed of 16 items. Three authors (SB, SM, MT) independently rated publications, using a dichotomous answer mode (criterion met versus not), after agreeing on the intervention and the primary outcome of interest, as expected in the user manual⁴². Disagreements were resolved by discussion. The answer "criterion met" counted 1 point otherwise "criterion not met" counted 0. Each study could reach a maximum of sixteen points.

Results

The search identified 40 articles: nine from Pubmed, 24 from SCOPUS and seven from the other mentioned databases. Nine out of the 40 studies were eligible for the review. The entire search and selection process for articles is illustrated in Figure 1.

The EDs considered were from USA^{7,13,29,33,35,38}, Australia³², Canada³⁰, Sweden²⁵, and India²⁶. Studies were all conducted between 2006 and 2014. All nine studies included were rated as quality lev-

el 4. While applying QI-MQCS, six out of nine publications totaled more than 10 points, three of them totaling 14 points^{7,28,29}. All selected publications received a positive evaluation for four of the sixteen criteria (1- Organizational motivation; 2- Intervention rationale; 3- Intervention description; 13- Penetration/Reach). None of the selected studies reached a positive evaluation for two of the sixteen criteria (10- Adherence/Fidelity; 11- Health outcomes).

All included publications were before-and-after studies^{7,13,26,28-30,32,33,35,38}. Patient volume of EDs in these studies ranged from 34,800²⁸ to approximately 95,000³⁸; Lean interventions were applied during a period ranging from one week³² to six months³⁶. In each study measured outcomes were compared with a previous period varying between three¹³ and 36 months⁷. Most of these studies were conducted at a single center^{13,26,28-30,32,33,35,38}. Four studies were carried out in Teaching Hospitals^{7,32,33,38}, and two studies were carried out in pediatric EDs^{13,28}.

The staff involved was generally comprised of not only clinicians and nurses, but also by assistants and engineers³⁰, providing suggestions to Lean design and implement changes in order to achieve the continuous improvements stated by Lean philosophy. In almost all the studies a quality improvement facilitator, often a Lean consultant, led the team. In the study by Dickson et al⁷, carried out in two academics and two community EDs, best results were obtained when Lean intervention was owned by the frontline workers who worked in the ED and the commitment of the leadership was principally involved sustaining the improvement. When both leadership commitment and frontline workers' involvement were missing, lack of improvement or even a worsening in LOS and patient satisfaction were observed.

In most cases Lean was the only approach used. In two studies typical Lean tools were combined with other approaches to process management. In particular, Chadha et al²⁶ described the integration of Lean and Queuing Theory, a mathematic model through which is possible determine the length and the waiting times of the queue. White et al³⁸ reviewed many engineering theory systems that included Lean methodologies, Six Sigma, Queuing Theory, Demand/Capacity Management, Theory of Constraints, Managing Variation, Forecasting and Scenario Analysis.

Table I summarizes Lean interventions and their effects on ED. None of the articles concerned the integration between primary care, sec-

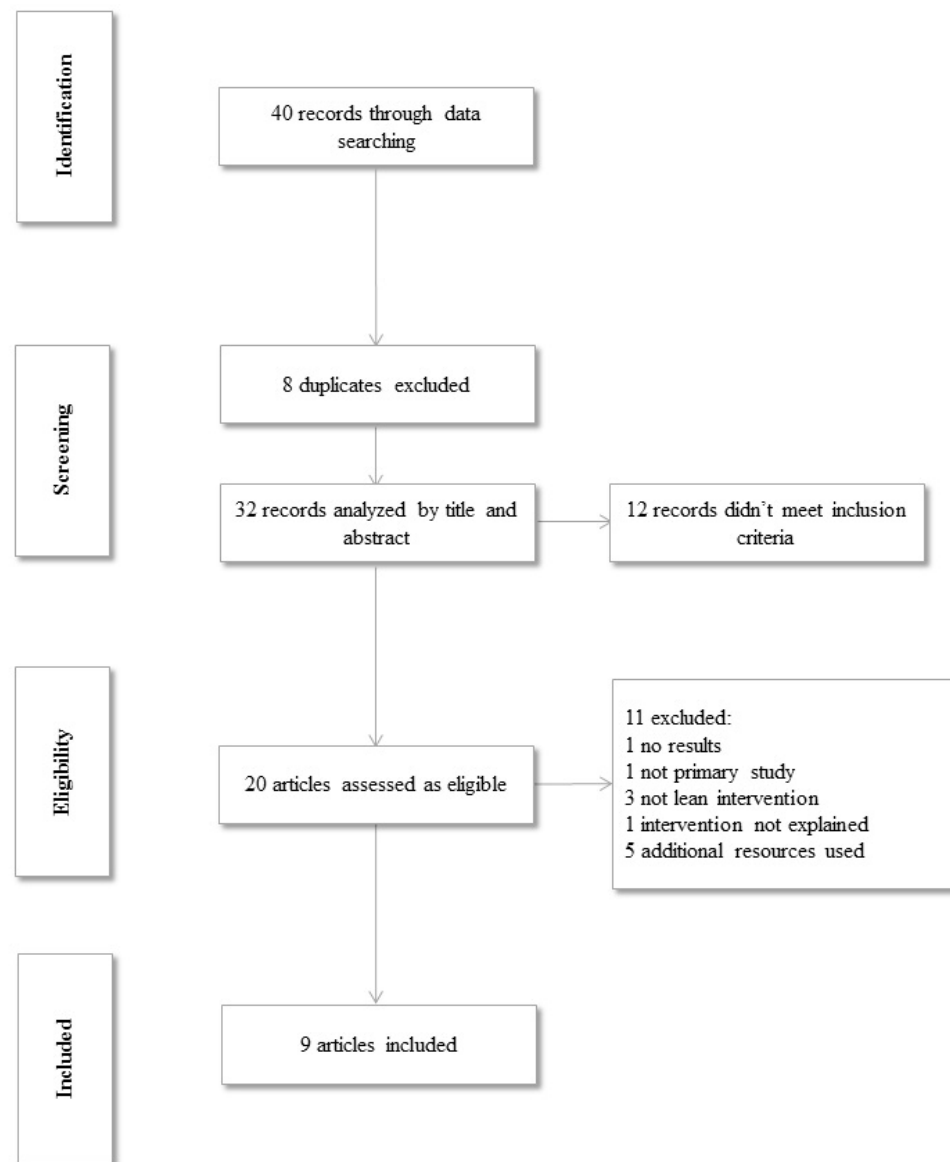


Figure 1. Study flow diagram.

ondary care, EDs and hospitals, to address the problem of overcrowding and hospital admissions in terms of timeliness.

In all studies, except two^{13,38}, project teams redesigned ED process using VSM to eliminate non-value-added activities. The main intervention taken was on the management of patient flow. Streaming of patients was performed in two or three categories, depending on the following: the likelihood to be admitted or not^{30,32}; the Emergency Severity Index²⁹; the Queuing Theory^{26,38}. In one case²⁸, no intervention in patient streaming was carried out, but a central-

ized management and control of patient flow was instituted.

One of the main bottlenecks was found to be the lack of space for initial assessment. This bottleneck was addressed by dedicating different areas for different type of patients^{27,30,33}. In one case, the areas were represented simply by a label attached to groups of existing beds within the ED³⁰. The staff was dedicated to the different areas and consisted of a nurse and a physician^{29,32}.

Other areas identified as places needing to improve were hospital bed shortages^{27,43-48}, wait for radiology²³ or the in-patient team²³.

Table 1. Characteristics of included studies and interventions description and results.

Author	Setting	Study design	Interventions	Results	Program duration/ follow-up
King et al, 2006 ³²	Teaching general hospital ED 50,000 pt/year, Australia	Before-after	– Patient flow design through VSM; – Patients streaming according to likelihood to be admitted or not; – Patients access to different areas depending on previous evaluation; – Areas with dedicated staff (nurse and physician); – No extra nursing or medical staff provided.	– Patient volume increase; – LOS decrease; – Admitted patients number decrease	1 week/12 months
Dickson et al, 2008 ³³	Teaching hospital ED 41,500 pt/year, USA	Before-after	– Managers and other participants education; – Patient flow design through VSM.	– LOS decrease; – Patient volume and admissions per month increase; – Direct expense per patient decrease; – Patient satisfaction increase.	1 month/24 months
White et al, 2014 ³⁸	Academic ED ca. 95,000 pt/year USA	Before-after	– Patient flow reorganization through existing rooms; – No staff or physical space modifications; – No added resources.	– LOS decrease; – Number of patients discharged increase; – Median exam room time decrease.	6 months/6 months
	ED A: Teaching Tertiary acute care hospital 38,000 pt/year;		– ED A: Kaizen event moderate by lean consultant (VSM, leadership involvement, boot camp, reallocation of staff);	– ED A: LOS, patient volume, LWSD (1 year FU) improvements, PS reduction;	
	ED B: Tertiary care community hospital 58,000 pt/year;		– ED B: Kaizen event led by a consultant team (videotape, redesigned staff work areas, audits, no committed leadership);	– ED B: LOS, patient volume, LWSD, and PS (3 years FU) improvements;	

Table continued

Table 1. (Continued). Characteristics of included studies and interventions description and results.

Author	Setting	Study design	Interventions	Results	Program duration/follow-up
Dickson et al, 2009 ⁷	ED C: Acute care hospital and Level II trauma center 85,000 pt/year; ED D: University hospital, tertiary care referral center and Level I trauma center 34,000 pt/year; USA	Before-after	– ED C: No Kaizen per se (improvement in radiology, minimal leadership involvement); – ED D: 5-day Kaizen event directed by a lean specialist (commitment of the department chairperson, communication board, periodic electronic communication).	– ED C: patient volume improvement (2 years FU), LOS increase, patient satisfaction decrease; – ED D: LOS, patient volume, PS increase, and admission per month improvements (2 years FU).	na/12 to 36 months
Chadha et al, 2012 ²⁶	ED, na pt/year, India	Before-after	– Patients streaming into 3 categories using VSM and the queuing theory; – Continuous Flow Cell creation to allow process of de-bottleneck.	– LOS decrease; – Patient volume increase.	na/na
Migita et al, 2011 ¹³	Pediatric Hospital ED 40,000 pt/year, USA	Before-after	– Medical and surgical specialists are asked to provide standardized inclusion and exclusion criteria for patient who may be admitted to their services; – Bed assignment is performed by an electronic admission bed request process; – Defining criteria according to which patient is considered ready to be admitted from ED perspective; – No additional resources used.	– LWBS decrease; – Standardized communication process	9 weeks/3 months

Table continued

Table I. (Continued). Characteristics of included studies and interventions description and results.

Author	Setting	Study design	Interventions	Results	Program duration/ follow-up
Murrel et al, 2011 ²⁹	General hospital ED 67,000 pt/year, USA	Before-after	– Patient flow design through VSM; – Implementation of Rapid Triage and Treatment; – Triage provided by a nurse and a physician; – Patients divided into 2 categories depending on their severity; – Patients access to different areas with dedicated staff (nurse and physician); – No changes in physician, nursing or technician staffing.	– LOS and LWBS decrease; – Patient volume increase; – Admitted patients number decrease.	1 month/6 months
Ng et al, 2010 ³⁰	Regional trauma, cardiac, neurosciences, renal and psychiatric referral centre ED 55,000 pt/year, Canada	Before-after	– Patient flow design through VSM; – Patients division into 3 groups according to the likelihood to be admitted or not; – Patients access to different areas with dedicated staff; – No additional staff or beds used.	– LOS and LWBS decrease; – Patient satisfaction increase; – Admitted patients number increase.	1 month/18 months
Mazzocato et al, 2012 ²⁸	⁶ Pediatric ED 34,800 pt/year, Swezia	Before-after	– Patient flow design through VSM; – Re-organization of process provided by multiprofessional team; – Centralized patient flow control performed by the flow manager; – No additional resources used.	– Number of patient seen and discharged within 4h increase; – Waiting time for the first visit decrease; – Patient volume increase.	1 month/24 months

ED: Emergency department; EMW: Emergency Medicine Ward; ESI: Emergency Severity Index LOS: length of stay; LWBS: left without being seen; na: not available; pt: patient; RAD: Rapid Assessment and Disposition; VSM: Value Stream Mapping; PS: percent of patients ranking overall ED care as “very good”.

Three studies^{30,32,35} tried to identify in which steps the communication between workers could obstruct or facilitate patient flow. Other Lean interventions were: computer systems implantation^{13,35}, changes in roles and responsibilities (e.g. nurse-physician care team members, flow managers, screening nurses)^{28,35}. Finally in seven studies, changes were evaluated and adjusted in an iterative way by Kaizen tool^{7,13,26,28-30,33}.

One study addressed more directly the problem of the access block. This study, conducted in a pediatric ED, the Lean intervention was focused on decreasing LOS for patients who had to be admitted to the hospital. After a standardization of inclusion and exclusion criteria for patients admissions and bed management, the authors assisted by an electronic system attained a reduction of approximately 10% in LOS¹³.

Lean interventions implementation showed increased patients volume^{7,26,28-30,32,33}, decreased LOS^{7,26,29,30,32,33,35} and LWBS^{7,13,29,30,35}, costs reduction³³ and increased patient satisfaction^{7,30,33}. However, in one of the four hospitals (Hospital C) included in Dickson et al⁷ these factors became worse the first and the second years after implementation. In particular, LOS increased and patient satisfaction decreased showing a trend towards worsening, while patient volume increased.

Discussion

Application and implementation of Lean in healthcare systems have been used for many years. All studies analyzed showed that the reorganization of healthcare services by Lean philosophy is still unknown and not yet standardized. Lean has represented the hoped-for solution after several failures and many times it has been based on previous and successful experiences^{28,29}. A previous review²⁴ analyzed the effectiveness of Lean methodology in the Emergency care setting. We decided to update the research in light of new studies and to focus on several dimensions not covered by Holden et al, such as duration and follow-up after the intervention and the integration with primary and secondary care settings.

Lean real innovation is the approach to problems management. Interventions are focused on the whole process rather than on a specific problem, involving not only the top management, but also the entire frontline staff. Employees are directly and indirectly affected by Lean interventions. During the process of improving the events

often used to teach people about lean while they improve specific processes⁷, workers have to improve their problem-solving skills, which may be judged either negatively (perception of being monitored, overloaded work)²⁸ or positively (employee participation and job control)⁴⁹. However, Kaizen leads to standardization⁵⁰ and consequently increases monotony. Therefore, Lean changes should be pursued with a human-centered approach (recognition of the value of people, patients, and workers), top management support, resource allocation and adaptation to the local context²⁴. Moreover, a strong leadership is required to build motivation, drive the changes and lead improvement projects^{7,24}. In fact, the biggest barrier to the success of Lean is often resistance to changes and the lack of collaboration between roles²⁴. No one study discussed staff satisfaction. A surrogate marker of workers' satisfaction was proposed by Dickson et al³³ by reporting physicians and nurses courtesy perceived by patients.

Another Lean tool implemented was work standardization based on assessment of the presumed "better way to do" that improved care process and could reduce the capability to adapt to unexpected variation^{51,52}. In most of these studies, the triage procedure was the most standardized^{25-33,35,37}. Managing patients' flow, starting from the arrival of patients to ED, had a positive impact on LOS, in particular on outpatient status. The streaming of patients at their arrival, deciding as soon as possible if they are admitted or not (through multidisciplinary teams evaluation) improves the ED performance and the appropriateness of admissions. On one hand, speeding up the time of decisions to admit patients, and on the other hand, allowing a smoothly flow of patients that do not need to be admitted, since care teams are different for both types of patients.

Induced changes as a result of Lean implicate not just improvement in processes or protocol but the possibility of reorganization of the ED layout to support new processes such as redesigning staff work areas or reorganizing consultation rooms^{7,30,33,35,37,38,53}. These structural changes have been demonstrated to be effective in improving, not only patient flow in ED^{28,30,35,37,38}, but also LOS and LWBS^{7,28,30,35,37,38,54}. One study³⁸ also considered resources needed for the reorganization of the ED. However, no one of the selected studies reported Lean interventions that require added expenses or costs, coherently with eligibility criteria.

Almost all studies considered showed that Lean interventions contributed to the EDs performance improvement. However, the literature is full of studies reporting successful Lean interventions, while little has been reported about the failed attempts²⁸. Many of these studies are single case studies, some quite anecdotal, many biased by a weak study design⁹. According to these results, the improvement showed by all the other studies should be evaluated by considering the quality of the studies and the possibility of publication bias⁵⁵. Surely, the development of specific tools for critical appraisal of quality improvement publication, such as QI-MQCS, is crucial. Nevertheless, studies often met minimum standard criteria and reached positive evaluation suggesting a more strict evaluation would produce worse results. It is possible a graduated criterion from “met” to “not met” is needed. Lean interventions, as all quality improvement interventions, differ from clinical interventions: this affects not only critical appraisal but also study design. Specific research design, appropriate statistical tests and outcome measures are needed. Indeed, most of the studies were conducted in a single center and without control, in some cases statistical analysis was lacking^{7,25,30,35} and the costs of interventions were usually not evaluated. Structural changes, dedicated staff (nurses, physicians, Lean consultants), implementation of Information Technology systems, as well as education and training of staff, have a cost that should not be overlooked in the evaluation of Lean regarding cost-effectiveness. More attention is needed in terms of sustainability. Furthermore, in the management of the access to ED, no study considered the importance of the integration between primary and secondary care and ED to reduce the number of accesses. Future studies should also take into account and emphasize facilitators for change and barriers to applications⁹.

Limitations

It is important to consider that the heterogeneity of methodology, outcome measures and reporting among the original articles could be a limit of this study. The duration of the interventions was different and in some cases the time pre and post intervention considered is not large enough to take into account seasonal flows and variations in terms of access in ED and nature of cases²⁹. This may entail distortion in results that were not systematically considered.

Conclusions

Managing hospitals through Lean becomes a prerogative of an excellent patient-oriented healthcare system: it seems to be critical for a better value-based healthcare²¹. Before a large-scale implementation, as there is a heated debate about the role of Lean in EDs, higher quality studies are needed to ascertain real effectiveness of Lean in EDs as compared to other quality improvement interventions. It would be also useful to address the problem of access block by a wider perspective, involving both primary care and hospitals, mostly dedicated to chronic diseases and complex patients. In fact, primary care has a main role in demand management (i.e. streaming and sending patients to ED only if necessary) and hospitals have to assure an easy access to the admitted patients (e.g. bed availability, timely discharge).

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Conflict of Interest

The Authors declare that they have no conflict of interests.

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