Improving Hospital Patient Flow: a systematic review.

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1. Introduction

Healthcare organizations are facing major challenges in responding to the growing demand for health services despite limited resources. Indeed, organizations have to manage critical tensions between cost saving, services improvement and equity of access, while maintaining the central focus on increasing value for patients. This topic is particularly challenging in the hospital setting, where the high cost of inpatient hospitalizations has led to a reduction of the number of acute hospital beds, against an increasing demand for inpatients admissions mainly from the Emergency Departments (Nugus et al. 2011; Mousazadeh et al. 2013; The Health Foundation 2013; The Organisation for Economic Co-operation and Development 2018). For this reason, improving hospital patient flow has become a policy priority, to effectively balance the increasing demands of an unknown and variable volume of patients with limited available hospital resources (Noon et al. 2003; Haraden and Resar 2004; Litvak et al. 2005; Eriksson et al. 2017).

Patient flow can be defined as 'how hospitals transfer patients between nursing units, and it is influenced by the levels of care required and the severity of patients' conditions' (Hendrich et al. 2004). Effective patient flow ensures that patients are present and ready at each point of care they need (Kriegel et al. 2015). In the hospital setting patient flow is particularly complex as it is high variable, it depends from timing patient inflow, patient's needs, response to treatment and the state of medical knowledge (Bohmer 2005). Moreover, several actors are involved at each level of the process (e.g. practitioners, nurses, administrative staff and the patient himself), and this makes coordination a critical issue.

Alexander et al. (2007) point out a need to make research more relevant to healthcare managers by expanding the methods utilized by health services researches. Understanding the factors contributing to hospital patient flow improvement is crucial to ensure care quality and patient safety, to control healthcare costs while increasing the level of productivity and to improve patient experience (Vissers et al. 2001; Litvak et al. 2005; Collins 2010; Lovett et al. 2014; Yarmohammadian et al. 2014). In recent years, hospital patient flow has been the object of several studies, many of them developed around and under the influence of 'Lean thinking' (Holden 2011; Hicks et al. 2015; Moraros et al. 2016) and this has stimulated wide debate among researchers on the future of Lean thinking in healthcare systems both as a theory and a set of practices (Radnor and Osborne 2013; McCann et al. 2015). Moreover, several simulation models have been developed to study how to promote efficient use of available bed capacity and to manage Emergency Department (ED) overcrowding (Bhattacharjee & Ray 2014; Salleh et al. 2017). However, in spite of the growing number of quality improvement initiatives to improve hospital patient flow and to reduce unwarranted variation, it is not clear what works and how managers could apply these initiatives considering their specific context.

Therefore, the aim of this paper is to highlight what works, for whom, why and in what circumstances in improving hospital patient flow. Accordingly, a systematic literature review was conducted to answer the following research questions: (i) Which actions are effective in improving hospital patient flow? (ii) Which outcomes are used to measure patient flow improvement? (iii) What are the enablers of success in the improvement initiative?

2. Theoretical background

It is recognized that healthcare organizations are complex dynamic systems (Plsek & Greenhalgh 2001; McDaniel et al. 2013; Holland 2006; McDaniel et al. 2009; Waring 2013) and this means that they continually evolve, making each setting somewhat unique and creating unpredictable results. In particular, hospitals are difficult organizations to study due to various factors including professional disciplines, ethical requirements and their large populations of patients with diverse medical conditions (Waring 2015).

The process of implementing quality improvement initiatives has received increasing attention over time (Shortell et al. 1995; McFadden et al. 2015; Berman et al. 2018). However, even though the use of quality improvement methods in healthcare is now widespread, the full implications of complexity in the design, conduct and evaluation of improvement initiatives have not yet been described (Brainard & Hunter 2015).

Kaplan et al. (2012) reported that the success of a quality improvement project is influenced by many key factors including external environment (i.e. external motivators and project sponsorship); organization (i.e. leadership, senior leader as project sponsor, culture, maturity of organizational quality improvement, physician pay structure); quality improvement support and capacity (i.e. data infrastructure, resource availability, workforce focus on quality improvement); microsystems (i.e. quality improvement leadership, culture supportive of quality improvement, capability for improvement, motivation to change); quality improvement team (i.e. diversity, tenure, leadership, physician involvement, subject matter expert, decision-making process, norms, quality improvement skill); triggers such as the presence of a specific event that stimulates a new emphasis on improving quality; and improvement projects being perceived as part of the organization's strategic goals.

When quality improvement is focused on patient flow, there are three main perspectives to be taken into account: patients' viewpoints, health professionals' needs and management objectives (Kriegel et al. 2015). The patient is the main actor going through all hospital's services and processes and somehow connecting them in the course of his/her specific journey (Ben-Tovim et al. 2008). Currently, staff only focus on the components they are responsible for, while patients move horizontally across hospitals, receiving care from different units (Ben-Tovim et al. 2008; Nugus et al. 2011). Recently, practitioners and researches have started debating on the role of patient as a customer ('the one we want to create value for') and as a co-creator of quality improvements (Groene & Sunol 2015; Bombard et al. 2018). From a management point of view, Jack and Powers (2008) identify efficiency, financial performance and quality-of-care outcomes as key areas of performance linked to demand and capacity management in healthcare. They argue that quality-of-care outcomes are increasingly considered by researchers, even if they are difficult to measure.

In accordance with this view, the aim of this review is to study existing literature on hospital patient flow focusing on implementation and outcomes achieved. We adopt Donabedian's model, known as the Structure Process and Outcome quality assessment tool, to schematize our results (Donabedian 1966). In this well-known model quality may be evaluated using outcomes (i.e. the effects of healthcare, such as survival and satisfaction), processes (i.e. whether medicine is properly practiced) and structure (i.e. the settings in which processes occur, and this includes elements such as the qualifications of healthcare staff, facilities, and equipment).

3. Methodology

A systematic literature review was performed in order to answer the research questions. The study protocol is based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses for Protocols guidance (PRISMA-P 2015) (Shamseer et al. 2015). This guidance consists of a 17-item checklist that facilitates the development and reporting of a systematic review. The items include the identification of data related to the research protocol, the description of the rationale for the review, the questions the review will address, the eligibility criteria, the information sources, the search strategy and the mode of data presentation (Moher et al. 2015).

Searches were conducted in Scopus, Web of Science, MEDLINE and The Cochrane Library for relevant English-language studies with human subjects from 1999 until October 31, 2018. The year 1999 was selected because of the publication of the report *To Err is Human* by the Institute of Medicine (Institute of Medicine 1999) that marks a significant change in the risk management and quality improvement approach in the healthcare system. Literature search strategies were developed using medical subject headings (MeSH) and text words. Due to the lack of standard terms to define hospital patient flow and its outcomes, a wide variety of search terms was used (e.g., hospital patient flow, patient journey, hospital bed capacity, outcome assessment, performance indicators).

As the focus of this paper is not how patient flow *should* be improved, but how it *has been* improved, studies on simulation and modelling were excluded.

For inclusion in this review, the articles had to fulfill the following criteria: quantitative and qualitative empirical primary studies with (adult) patients receiving acute hospital inpatient care; randomized or non-randomized trials, prospective or retrospective cohort studies, case-control studies. The following studies were excluded: psychiatric and pediatric hospital units (because of the special care needs for patients and caregivers); outpatients and rehabilitation settings (as we intended to focus on hospital patient flow);

descriptive studies lacking comparison groups, including case reports; modelling and simulation studies that show potential improvement of the patient flow, but have not been applied in the field; reviews, editorials and policy statements without direct empirical support. Table I provides a summary of the search strategy. The complete search strategy is reported in the Appendix.

Table I: Inclusion and exclusion criteria

In order to evaluate improvements in hospital patient flow, the following outcomes were considered: efficiency outcomes (e.g., hospital length of stay [LOS], Emergency Department waiting times); quality of care outcomes (e.g., mortality, proportion of patients readmitted to hospital within 30 days); financial outcomes (e.g., costs of labor); patient satisfaction and experience; staff perception and satisfaction.

The examination of inclusion criteria was performed in three steps: (i) Titles examination; (ii) Selection of papers, excluding duplicates (iii) Abstracts and Full-Text examination to select articles responding to the research question. Each stage of the literature review process can be viewed in Figure 1.

Figure 1: Literature review Flow Diagram

A critical appraisal of included studies was performed by using the Quality Improvement Minimum Quality Criteria Set (QI-MQCS) (Hempel et al. 2015). The QI-MQCS is a specific tool for quality improvement studies assessment. It is composed of 16 items addressing the following domains: Organizational Motivation, Intervention Rationale, Intervention Description, Organizational Characteristics, Implementation, Study Design, Comparator, Data Source, Timing, Adherence/Fidelity, Health Outcomes, Organizational Readiness, Penetration/Reach, Sustainability, Spread and Limitation. Table II describes each domain.

Table II: Quality Improvement Minimum Quality Criteria Set (QI-MQCS) domains (Hempel et al. 2015)

4. Results

Figure II shows the number of records at each stage of the literature review process. After removing duplicated items, of 368 potentially relevant studies, 213 full-text articles were included for review. Of these, 38 key papers were identified for presentation, citation and discussion in this review.

Out of 38, 24 were performed in the Emergency Department (ED) setting, sometimes with other closely related Departments taken into consideration (e.g. ICU, Coronary Unit, Surgical or Medical Departments); 3 studies were performed in a Critical Unit Service setting (Intensive Care, Trauma Intensive Care or Coronary Unit); 1 in an Operating Room, 1 in an Orthopedic Unit, 1 in a Neuroscience Unit and 1 in General Medicine and Surgery Units. Only 7 studies analyze interventions to improve hospital patient flow covering the whole hospital (Yancer et al. 2006; Ortiga et al. 2012; Jweinat et al. 2013; Lovett et al. 2014; Richardson et al. 2017; Sheridan et al. 2017; Odom et al. 2018). Detailed characteristics and results of included studies are described in the Appendix.

Table III reports the critical appraisal of the included studies by assigning a score equal to 1 to each item met of the QI-MQCS. The score assigned to the studies for each item is described in the Appendix. The studies on average scored 10 out of 16 (max: 14; min: 6). The weaker aspects in the studies are: a description of the intervention's ability to be spread or replicated (lacking in 33 studies), evidence of adherence or a mechanism ensuring compliance with the intervention (lacking in 30 studies), a description of health-related outcomes (lacking in 24 studies).

Table III: Quality assessment of studies included according to the QI-MQCS

4.1. Actions to improve Hospital Patient Flow

Management of patient flow is multifaceted and driven by several internal and external key factors: patient acuity, bed management, internal communication, new technologies and many others. Consequently, a wide range of interventions to improve hospital patient flow is reported by the studies included in this review. The structure model in Figure 2 reports the main actions emerging from the review.

A detailed list of actions to improve hospital patient flow and of measures adopted is reported in the Appendix.

Figure 2: Theoretical framework of actions and outcomes linked to patient flow improvement

4.1.1. Structure

People. For most of the studies, actions to improve patient flow included an increase in staff or the identification of a new function role, in particular among nurses. Among these, the transfer coordinator (Cha et al. 2009) or the navigator role (Fulbrook et al. 2017; Richardson et al. 2017) are experienced nurses fully assigned to the ED, and whose function is to coordinate and facilitate the patient transfer process and to enhance ED throughput. Fulbrook et al. (2017) emphasizes that this role works best when relationships are perceived as collaborative and provide assistance to improve system flow.

Only three authors reported the use of performance incentive plans among actions to improve hospital patient flow (Jweinat et al. 2013; Vermeulen et al. 2014; Svirsky et al. 2013). In particular, Jweinat et al. (2013) reported a program that provides financial incentives to all employees if specific, measurable, hospital wide goals were met including key performance patient flow measures, such as the percentage of 11:00 a.m. discharges.

Infrastructure. Physical layout change or expansion has generally been tested in combination with reorganization of the work teams and redesign of the workflow (Araya et al. 2013; Chadanga et al. 2012; Dickson et al. 2009; Driscoll et al. 2015; Elder et al. 2015; Evans et al. 2011; Hendrich et al. 2004; Lovett et al. 2014; Mumma et al. 2014; Borenstein et al. 2016; Odom et al. 2018; Perry et al. 2010; Sánchez et al. 2018; Twanmoh et al. 2006; Yancer et al. 2006; Williams et al. 2011; Zocchi et al. 2015).

In the ED setting, an increase of beds was associated with no significant change in the percentage of patients who left without being treated, or with an increase in ED boarding hours (Mumma et al. 2014) while a dedicated surgical assessment area involving a dedicated acute surgical team result in a significant reduction in hospital stay and in an improvement in ED efficiencies (Perry et al. 2010).

Hendrich et al. (2004) tested the use of acuity-adaptable rooms to provide an improved care environment for patients who required progressive care. The design of the new rooms was performed in order to shift indirect time back to the nurses and patients' care by reducing the steps necessary for nurses to obtain supplies, reduce transfers of patients, maximize technology for efficiency, and have information for patients and caregivers readily available at the point of care. Significant improvements were achieved in quality and operational cost such as a large reduction in clinician handoffs and transfers; a reduction in medication error and patient fall indexes; improvements in predictive indicators of patients' satisfaction; decrease in budgeted nursing hours per patient day with increased inpatient days per bed (Hendrich et al. 2004).

Information Technology. The introduction of a single web-based technology platform is one of the key actions when faced with the management of patient flow in the whole hospital (Lovett et al. 2014). By collecting data from various systems and providing a patient flow dashboard and real-time tracking of all patient flow activity, a bed management system can optimize efficiency and communication, alert staff and provide timeliness information to end users (Jweinat et al. 2013; Lovett et al. 2014).

4.1.2. Process

In order to standardize the admission and discharge process a series of initiatives were adopted. These include: a set of hospital-wide actions to standardize the admission process and to predict and anticipate patient discharge. In the ED setting, interventions are related to initial assessment at triage by including

physicians in triage, simplifying triage documentation and introducing quick triage protocols (Imperato et al. 2012; Arya et al. 2013; Soong et al. 2013; Svirsky et al. 2013; Chan et al. 2014; Elder et al. 2015; Zocchi et al. 2015). In the surgical setting, a set of integrated recommendations (i.e. anticipated discharge date, notifying family members of the discharge time and defining standard discharge responsibilities for key individuals) involving the Operating Room, the Intensive Care Unit and Surgical Care Units improved the admission and discharge process (Williams et al. 2011; Amato-Vealey et al. 2012).

Several authors report that daily proactive bed management obtains a better use of available resources and avoids delays in the hospitalization of patients in severe clinical conditions (Alikhan et al. 2009; Cha et al. 2009; Howell et al. 2010; Chadanga et al. 2012; Healy-Rodriguez et al. 2014). In particular, integrating multiple services into a single, centralized Patient Flow Management Center, that manages supply and demand for hospital inpatients, is related to improvements in boarding time from ED to bed assignment and bed turnover time (Lovett et al. 2014; Healy-Rodriguez et al. 2014; Ortiga et al. 2012; Richardson et al. 2017).

The effectiveness of multi-professional teams to improve patient flow and clinical outcomes have been tested by several studies (Alikhan et al. 2009; Amato-Vealey et al. 2012; Borenstein et al. 2016; Chadanga et al. 2012; Dickson et al. 2009; Elliot et al. 2015; Evans et al. 2011; Healy-Rodriguez et al. 2014; Jweinat et al. 2013; Lovett et al. 2014; Muntlin Athlin et al. 2013; Odom et al. 2018; Ortiga et al. 2012; Sánchez et al. 2018; Yancer et al. 2006). Some examples include the development of a Hospital Medicine ED Team consisting of hospital medicine physicians, ED physicians, social workers, and nurses (Chadanga et al. 2012); the development of a multi-professional team responsible for the whole care process for a group of patients (Muntlin Athlin et al. 2013); the incorporating of one logistic manager and two registered nurses in a logistics management program (Healy-Rodriguez et al. 2014). A major focus on workflow redesign is evaluated by Borenstein et al. (2016) who reported the positive impact of restructuring routine workflows on general medical inpatient units, by training, and by organizing existing personnel into interprofessional teams.

Finally, many authors emphasize the importance of introducing multidisciplinary teams into the patient flow redesign project. Professionals from top and middle management and from front-line staff were involved in corporate patient flow performance teams (Alikhan et al. 2009) or in a Steering Committee (Evans et al.2011). Top management involvement is reported as a key factor both in the orientation and promotion of the project, and in the strategic definition phase of any incentives for employees in order to achieve improvement goals. In particular, the need to promote significant incentives, such as financial compensation or recognition, is reported in order to facilitate the frontline providers' involvement (Driscoll et al. 2015; Svirsky et al. 2013). Project management work groups can include nursing managers, patient transport managers, housekeeping managers, case manager supervisors, bed managers, and many other professional roles (Driscoll et al. 2015; Evans et al. 2011; Sánchez 2018). External consultants were included in the working groups to guide and train employees in the newly adopted methodologies (Alikhan et al. 2009; Castillo et al. 2011; Driscoll et al. 2015; Jweinat et al. 2013; Lovett et al. 2014; Vermeulen et al. 2014; Zocchi et al. 2015) or to redesign physical layout and environments (Hendrich et al. 2004). Sánchez et al. (2018) affirm that a consultant who masters the 'lean methodology' is mandatory in each lean project.

Only one study describes the involvement of patients in the redesign of patient flow. Ortiga et al. (2012) reported the creation of an interdisciplinary team of clinicians, hospital administrators and patients/families to examine bottlenecks and improvement areas in service delivery in order to improve hospital capacity. However, the degree of patient involvement and what solutions the patients proposed are not reported.

4.2. Outcomes measures in improving Hospital Patient Flow

Efficiency. All of the thirty-eight research studies analyzed in this review were directly related to efficiency organizational performance indicators. Most of them refer to the ED input-throughput-output process and include ED patients' LOS, ED waiting times and ED to Intensive Care Unit throughput. Hospital capacity is evaluated by measuring hospital time of day capacity and surgical cancellations due to no beds (Alikhan et al. 2009; Evans et al. 2011; Jweinat et al. 2013; Ortiga et al. 2012). Admission and discharge processes are measured with indicators such as the number of same day of surgery admissions, percentage of patients placed in second-choice unit (Jweinat et al. 2013; Ortiga et al. 2012; Driscoll et al. 2015), percentage of discharge planning and 11:00 a.m. discharges (Ortiga et al. 2012; Sheridan et al. 2017; Jweinat et al. 2013).

Hospital LOS, stratified for inpatients who did not undergo surgery, inpatients who underwent operations and scheduled patients' LOS, was analyzed according to the setting in which the intervention was performed (Bhakta et al. 2013; Borenstein et al. 2016; Elliott et al. 2015; Jweinat et al. 2013; Ortiga et al. 2012; Yancer et al. 2006; Perry et al. 2010).

Financial. Financial performance was analyzed by three studies. A more efficient redesign of the care environment for patients who required progressive care significantly increased available nursing time and permitted a reduction in budgeted staffing care hours (Hendrich et al. 2004). A simple cost-benefit analysis was undertaken by considering ED triage category; primary diagnosis, and whether the patient was admitted to hospital or not (Fulbrook et al. 2017) and by analyzing the space and staff investment (Lovett et al. 2014).

Clinical quality of care. Only ten studies analyzed quality of care outcomes. In-hospital mortality and death after ED assessment are the most common clinical outcomes analyzed (Bhakta et al. 2013; Borenstein et al. 2016; Cha et al. 2009; Elliott et al. 2015). Additional outcomes influenced by patient flow improvement are: re-presentation to the ED within 48 / 72 hours and unplanned readmission within 7 – 30 days (Vermeulen et al. 2014; Elder et al. 2015), hospital complications (measured as diagnoses not present on admission) (Borenstein et al. 2016) and medication error and patient fall indexes (Hendrich et al. 2004).

Perceived Quality of Care. Only six studies analyze patient satisfaction with the service provided and most of them do not specify the key areas of analysis (Alikhan et al. 2009; Dickson et al. 2009; Yancer et al. 2006; Williams et al. 2011; Lutze et al. 2014; Fulbrook et al. 2017). Hendrich et al. (2004) reported a reduction in predictive indicators of patients' dissatisfaction referred to as 'not made to feel less nervous or withdrawn', 'not treated with respect and dignity', 'nurses not friendly and caring' by testing the use of acuity-adaptable rooms. Chadanga et al. (2012) reported on staff perception and satisfaction. Although the sample was limited, the authors collected data on the agreement of physicians and nurses after the implementation of a hospital medicine ED team, with respect to the following statements: improved quality of care, improved communication, improved collegiality and clinical decision-making, improved patient flow, hospital medicine ED team as an asset to the Hospital. Others studies analyzed indicators such as retention of nurses after implementation and collaboration between hospital units (Castillo et al. 2011; Hendrich et al. 2004; Chadanga et al. 2012; Brown et al. 2015; Driscoll et al. 2015). In almost all studies, there was no concurrent collection of data relating to the effect of the program changes on patient and staff satisfaction. No study has been found on the effect of an improvement on the patients' and caregivers' experience.

4.3. Enablers in patient flow improvements

Since all interventions require a significant change in the departments' organization, some authors point out key factors needed for success. These are summarized below using Kaplan's model (2012).

External environment. Regional regulations and incentives that stimulate the organization to improve its performance and quality in patient flow management are reported. (Evans et al. 2011; Soong et al. 2013). In particular, when dealing with the priority placement of patients and with the problem of ambulance diversion, incentives for integration between hospitals and improvement of their internal processes are adopted (Castillo et al. 2011).

Project's strategic importance to the organization. Previous failed attempts to improve hospital patient flow are due to the lack of a comprehensive strategy and of interdependent institution-wide coordination (Healy-Rodriguez, 2014; Jweinat et al. 2013; Lovett et al. 2014). For this reason, top management commitment is recognized by many authors as one of the primary factors for the project's development (Yancer et al. 2006; Alikhan et al. 2009; Dickson et al. 2009; Amato-Vealey et al. 2012; Evans et al. 2011; Ortiga et al. 2012; Jweinat et al. 2013; Lovett et al. 2014; Mumma et al. 2014). Moreover, the success of the project's implementation depends on strong executive oversight with clear accountability, engagement of the ED leadership team and subject matter expertise of those charged with implementation (Richardson et al. 2017).

Quality Improvement support and capacity. A key factor for quality improvement initiatives is the knowledge and use of the tools of quality improvement, as well as a significant investment in building expertise in data capture, analysis and management (Evans et al. 2011). Moreover, the institution of standardized performance indicators at all levels of the organization provides feedback on personal work and

can improve the adherence of professionals to the improvement program (Alikhan et al. 2009; Evans et al. 2011; Jweinat et al. 2013; Odom et al. 2018; Richardson et al. 2017; Soong et al. 2013; Zocchi et al. 2015). Visual management tools also help all the actors involved to achieve improvement goals and to see the whole patient process by the use of Information Technology (Alikhan et al. 2009; Castillo et al. 2011; Chadanga et al. 2012; Driscoll et al. 2015; Evans et al. 2011; Healy-Rodriguez et al. 2014; Jweinat et al. 2013; Mumma et al. 2014; Odom et al. 2018; Sánchez et al. 2018; Sheridan et al. 2017; Yancer et al. 2006).

Quality improvement team. Alikhan et al. (2009) highlights the essential factor of 'Getting the right people on the bus' by involving in the core change team a critical mass of talent and an optimal mix of functional skills. The authors report that beyond methodological knowledge, strong interpersonal and facilitation skills and commitment to the mandate, teamwork and a sense of optimism are key.

Microsystem. Effective communication between the different hospital units and inter/intradepartmental and interdisciplinary collaboration play a key role in patient flow improvement. This can be achieved by cross-department planning and sharing information, by enhancing communication with medical departments and between nurses on different patient care units (Jweinat et al. 2013; Chan et al. 2014; Brown et al. 2015; Driscoll et al. 2015). Staff empowerment, standardization of best practices, and culture change in the environment may also improve clinical, operational, and financial outcomes (Jweinat et al. 2013; Zocchi et al. 2015).

5. Discussion

The aim of this systematic review was to synthesize the findings of studies that attempted to improve hospital patient flow by identifying measures, outcomes and enablers of success. Due to the variety of terms used to indicate this process, a search was performed including all the terms and their respective synonyms and resulted in the identification of thirty-eight key papers.

On assessing the quality of studies included according to the QI-MQCS, only a small part of them were found to be designed with any strong methodology. Accordingly, almost all the studies reported the impossibility of generalizing the results achieved as a limitation. This is due to the variety of the hospitals in which improvements were implemented. Moreover, some studies reported that the introduction of multiple interventions, with multivariate analysis not being feasible, and no comparison tool available, prevented any causal relationship from being inferred from the before-and-after results (Ortiga et al. 2012, Lovett et al. 2014).

Almost all the studies were performed in the ED setting, since they were motivated by the urgency of managing ED overcrowding and its effect on ambulance diversions, waiting times and patient care quality. However, EDs do not exist in isolation, and authors emphasized the need for a hospital system-wide approach to improve the overall patient-flow performance (Alikhan et al. 2009; Castillo et al. 2011; Chadanga et al. 2012; Evans et al. 2011). Despite the complexity of the variables involved in patient-flow management, only the study of the whole hospital process can identify system improvements and integration between the different hospital services. Indeed, multiple hospital units, departments and support services are involved in providing inpatient resources and many processes have to be performed in synchrony in order to smooth hospital patient flow. Therefore, studies report a wide range of actions, varying from interventions to improve admission and discharge processes, to taking advantages of the use of technology and redesigning an effective work-flow.

The literature analysis reveals that most of the existing measures of patient flow performance focus on process indicators, while only a few authors analyze clinical outcomes, patient satisfaction and quality of care outcomes. Moreover, traditional measures of the effect of improvements are often productivity-based, and others measures such as patient safety, patient experience, and quality of service as perceived by the patient are seldom included. These results are in line with a recent systematic review where authors reported how studies on patient flow improvement rarely focus on the patient's perspective (patient journey) beyond that of the organization (patient flow) (Winasti et al. 2018). This seems to be in conflict with the nature of the healthcare service, which is mainly characterized by high patient expectations on service quality despite limited available resources (Kros & Brown 2013). As from the patient's experience, an admission as an

inpatient in an acute hospital is a major event, his/her perspective should be studied more and evaluated with defined and shared indicators.

With regard to key success factors, this review shows that initiatives to improve hospital patient flow are successful when all the actors are involved, together with a strong top-management commitment. Studies emphasize the importance of top-management involvement as well as the involvement of front-line professionals, but few studies discuss patient involvement. Even though in the last few years growing attention has been paid to patient and caregiver involvement in order to improve health services starting from their experience (Bowen et al. 2013; Donetto et al. 2014; Locock et al. 2014), these results are in line with the recent study by Groene & Sunol (2015) that report how patients are rarely involved in process redesign. On this subject, literature still has many fields to explore in depth, starting from defining the different levels of patient involvement in health services to creating services really centered on patient needs (Castro et al. 2016; Gustavsson and Andersson 2017). The shift to a patient centered approach requires the development of a culture in which all stakeholders are empowered and encouraged to make improvements from a patient perspective as well as a process efficiency perspective.

The results of this review bring together measures, factors and variables affecting hospital patient flow improvement in order to inform health-care managers on how to act effectively in their context. The analyzed studies emphasize key issues to manage a complex hospital process. Interventions to improve patient flow can be performed at various organizational levels (i.e.: infrastructure, information technology, multidisciplinary teams) but the biggest challenge remains to integrate multiple actors and processes. However, further research on patient flow improvement in a hospital system-wide approach is needed. In particular, this review points out the need of improving hospital patient flow, both by analyzing the whole process throughout the hospital and by considering the patient's perspective. This will allow hospital productivity to be improved without losing the focus on added value for the patient.

This review presents some limitations. Firstly, the review was limited to 1999-2018. Considering that most of the studies are published in the last years of the period assessed, very recent studies may have been excluded. Secondly, due to the exclusion criteria applied and to the keywords used, this review may have excluded important studies in other healthcare settings (i.e. outpatients and psychiatric settings) that could contribute to the interpretation of results, probably mainly considering the patient's perspective. Finally, studies show a variability of research design and setting. Therefore, the possibility of reaching clear conclusions about interventions to improve hospital patient flow is limited by the mixed results and the heterogeneity of the study designs.

6. Conclusion

Hospital patient flow is complex and multidimensional, since it is determined by institutional and organizational variables, as well as patients' conditions. Achieving improvements in hospital patient flow requires the design and implementation of complex, multifaceted, and coordinated interventions. Further research should evaluate the different perspectives and needs of the relevant actors by considering clinical outcomes, providers' point of view and patients' experience and satisfaction, besides process efficiency indicators.

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Appendix to: Improving Hospital Patient Flow: a Systematic Review

Title: Improving Hospital Patient Flow: a systematic review of the literature

Table I: Inclusion and exclusion criteria

Items	Criteria
Population	Patients (adults) receiving inpatient hospital care
Interventions	Health system interventions for the purpose of improving hospital patient flow (examples include increasing hospital capacity, instituting multidisciplinary teams). Observational studies are included.
Comparator	Experimental studies: no interventions
Outcome	Efficiency outcomes (e.g., hospital length of stay, emergency department waiting times) Quality of Care outcomes (e.g., mortality, proportions of patients readmitted to hospital within 30 days) Financial outcomes (e.g., costs of labor) Patient satisfaction and experience Staff perception and satisfaction
Timespan	1999-October 31, 2018
Setting	Inpatient medical or surgical (not psychiatric or pediatric) units at acute care hospitals
Other criteria	Language: English Admissible designs: randomized controlled trials; non randomized trials; prospective and retrospective cohort studies; case-control studies Non-admissible designs: descriptive studies lacking comparison groups, including case reports; modelling and simulation studies with no application in a real context; reviews, editorials and policy statements without straight empirical support.

Table II: Quality Improvement Minimum Quality Criteria Set (QI-MQCS) domains (Hempel et al. 2015)

Domain		Description
1.	Organizational motivation	Organizational problem, reason or motivation for the intervention
2.	Intervention rationale	Rationale linking the intervention to its expected effects
3.	Intervention description	Change in organizational or provider behavior
4.	Organizational characteristics	Demographics or basic characteristics of the organization
5.	Implementation	Temporary activities used to introduce potentially enduring changes
6.	Study design	Study design and comparator
7.	Comparator	Information about comparator care processes
8.	Data source	Data sources and outcome definition
9.	Timing	Timing of intervention and evaluation
10.	Adherence/fidelity	Adherence to the intervention
11.	Health outcomes	Patient health-related outcomes
12.	Organizational readiness	Barriers to and facilitators of readiness
13.	Penetration/reach	Penetration/reach of the intervention
14.	Sustainability	Sustainability of the intervention
15.	Spread	Ability to be spread or replicated
16.	Limitations	Interpretation of the evaluation

Table III: Quality assessment of studies included according to the QI-MQCS

Author	Year of publication	Country	Study Design	Setting	QI-MQCS Score
Borestein et al.	2016	USA	Cluster randomized controlled	General medical/surgery hospital units	**14**
Sánchez et al.	2018	Spain	Prospective pre-post	ED	**14**
Soong et al.	2013	Canada	Retrospective pre-post	ED and General Internal Medicine Department	**14**
Fulbrook et al.	2017	Australia	Prospective controlled	ED	**13**
Hendrich et al.	2004	USA	Prospective pre-post	Coronary Critical Unit and its step-down medical unit	**13**
Jweinat et al.	2013	USA	Prospective pre-post	Hospital	**13**
Bhakta et al.	2013	USA	Retrospective pre-post	Trauma Intensive Care Units	**12**
Chadanga et al.	2012	USA	Prospective pre-post	ED	**12**
Healy-Rodriguez et al.	2014	USA	Retrospective pre-post	ED	**12**
Howell et al.	2010	USA	Retrospective pre-post	ED, ICU and Coronary Care Unit	**12**
Muntlin Athlin et al.	2013	Sweden	Prospective non-randomized cohort	ED	**12**
Ortiga et al.	2012	Spain	Cross-sectional pre-post	Hospital	**12**
Richardson et al.	2017	Australia	Prospective pre-post	ED, Hospital	**12**
Alikhan et al.	2009	Canada	Prospective pre-post	ED	**11**
Cha et al.	2009	South Korea	Prospective pre-post	ED	**11**
Elder et al.	2015	Australia	Retrospective cohort	ED	**11**
Elliott et al.	2015	USA	Retrospective interrupted time series	ED, Medical ICU	**11**
Lovett et al.	2014	USA	Prospective pre-post	Hospital	**11**
Perry et al.	2010	New Zealand	Prospective pre-post	ED and Surgical Department	**11**
Zocchi et al.	2015	USA	Prospective pre-post	ED	**11**
Arya et al.	2013	USA	Retrospective pre-post	ED	**10**
Brown et al.	2015	USA	Retrospective pre-post	ICU and OR	**10**
Castillo et al.	2011	USA	Retrospective pre-post	ED	**10**
Chan et al.	2014	China	Prospective pre-post	ED	**10**
Dickson et al.	2009	USA	Prospective pre-post	ED	**10**
Mumma et al.	2014	USA	Retrospective cohort pre-post	ED	**10**
Vermeulen et al.	2014	Canada	Retrospective cohort pre-post	ED	**10**
Evans et al.	2011	Canada	Pre-post	ED, ICU and Hospital Departments	**9**
Imperato et al.	2012	USA	Retrospective pre-post	ED	**9**
Sheridan et al.	2017	Canada	Prospective pre-post	Hospital	**9**
Driscoll et al.	2015	USA	Pre-post	Neuroscence service line	**8**
Odom et al.	2018	USA	Pre-post	ED, Hospital	**8**
Svirsky et al.	2013	USA	Prospective with control group	ED	**8**
Yancer et al.	2006	USA	Pre-post	Hospital	**8**
Amato-Vealey et al.	2012	USA	Pre-post	Operation Room, Intermediate Care Unit, Surgical Floors	**6**
O'Connel et al.	2008	Australia	Pre-post	ED	**6**
Twanmoh et al.	2006	USA	Not cited	ED	**6**
Williams et al.	2011	Canada	Prospective pre-post	Orthopaedic Surgery Center	**6**

Figure 1: Literature review Flow Diagram

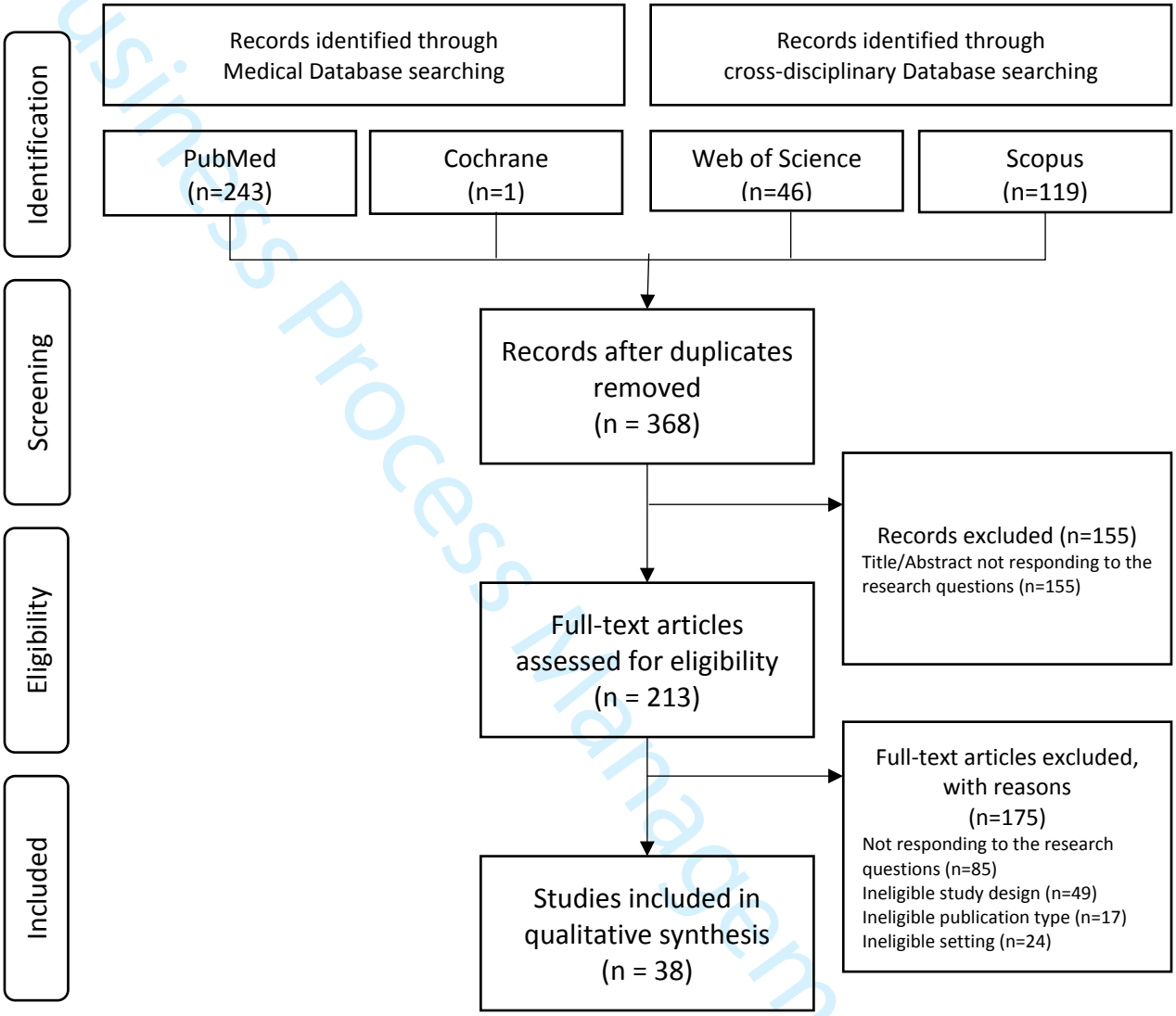
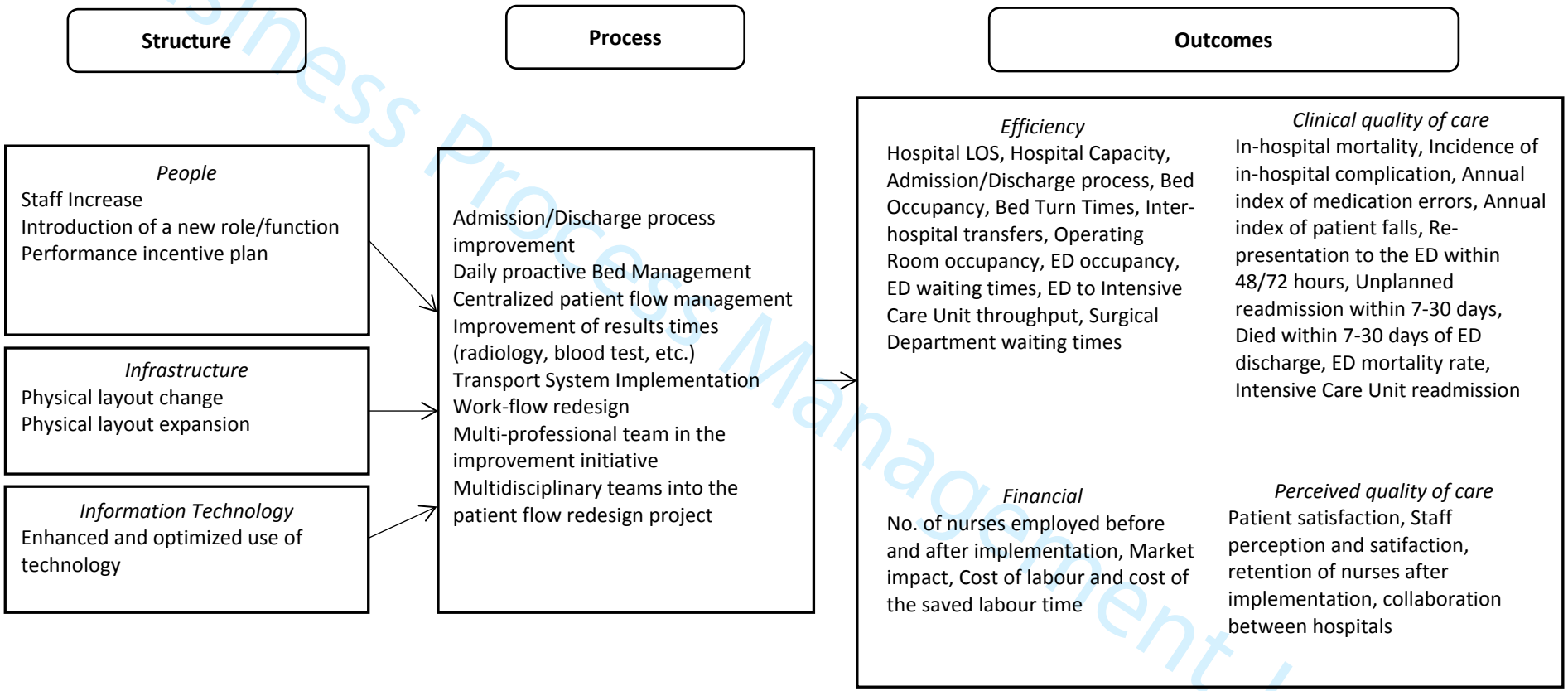


Figure 2: Theoretical framework of actions and outcomes linked to patient flow improvement



Appendix to: Improving Hospital Patient Flow: a Systematic Review

1. Search strategy

	Medline	
#	Searches	Records
#37	Search ((((((Hospitals) OR Hospital*)) AND ((((patient flow) OR patient journey) OR patient care process) OR workflow)) AND ((((Patient Transfer/organization & administration*) OR Patient transfer*) OR Patient flow logistic) OR Patient flow logistics)) AND ((((((((((Hospital Bed Capacity) OR Inpatient capacit*) OR Inpatients) OR Hospital access*) OR Access block*) OR Bed-block*) OR Bed occupanc*) OR ((Bed utilization) OR Bed utilisation)) OR Patient throughput) OR Patient discharg*)) AND ((((((((((Outcome Assessment (Health Care)) OR Treatment Outcome) OR Process performance) OR key performance indicators) OR Efficiency, Organizational*) OR Hospitalization/statistics & numerical data) OR waiting times) OR perioperative patients delay) OR patient safety) OR Patient-Centered Care/standards) OR Patient-Centered Care/method*) Filters: Publication date from 1999/01/01 to 2018/10/31; English	243
#36	Search ((((((Hospitals) OR Hospital*)) AND ((((patient flow) OR patient journey) OR patient care process) OR workflow)) AND ((((Patient Transfer/organization & administration*) OR Patient transfer*) OR Patient flow logistic) OR Patient flow logistics)) AND ((((((((((Hospital Bed Capacity) OR Inpatient capacit*) OR Inpatients) OR Hospital access*) OR Access block*) OR Bed-block*) OR Bed occupanc*) OR ((Bed utilization) OR Bed utilisation)) OR Patient throughput) OR Patient discharg*)) AND ((((((((((Outcome Assessment (Health Care)) OR Treatment Outcome) OR Process performance) OR key performance indicators) OR Efficiency, Organizational*) OR Hospitalization/statistics & numerical data) OR waiting times) OR perioperative patients delay) OR patient safety) OR Patient-Centered Care/standards) OR Patient-Centered Care/method*) Filters: English	259
#35	Search ((((((Hospitals) OR Hospital*)) AND ((((patient flow) OR patient journey) OR patient care process) OR workflow)) AND ((((Patient Transfer/organization & administration*) OR Patient transfer*) OR Patient flow logistic) OR Patient flow logistics)) AND ((((((((((Hospital Bed Capacity) OR Inpatient capacit*) OR Inpatients) OR Hospital access*) OR Access block*) OR Bed-block*) OR Bed occupanc*) OR ((Bed utilization) OR Bed utilisation)) OR Patient throughput) OR Patient discharg*)) AND ((((((((((Outcome Assessment (Health Care)) OR Treatment Outcome) OR Process performance) OR key performance indicators) OR Efficiency, Organizational*) OR Hospitalization/statistics & numerical data) OR waiting times) OR perioperative patients delay) OR patient safety) OR Patient-Centered Care/standards) OR Patient-Centered Care/method*)	269
#34	Search ((((((((((Outcome Assessment (Health Care)) OR Treatment Outcome) OR Process performance) OR key performance indicators) OR Efficiency, Organizational*) OR Hospitalization/statistics & numerical data) OR waiting times) OR perioperative patients delay) OR patient safety) OR Patient-Centered Care/standards) OR Patient-Centered Care/method*	432847
#33	Search Patient-Centered Care/method*	2494
#32	Search Patient-Centered Care/standards	2011
#31	Search patient safety	130503
#30	Search perioperative patients delay	675
#29	Search waiting times	20149
#28	Search Hospitalization/statistics & numerical data	4
#27	Search Efficiency, Organizational*	20830
#26	Search key performance indicators	3331
#25	Search Process performance	71644
#24	Search Treatment Outcome	1142036
#23	Search Outcome Assessment (Health Care)	201836
#22	Search (((((((((Hospital Bed Capacity) OR Inpatient capacit*) OR Inpatients) OR Hospital access*) OR Access block*) OR Bed-block*) OR Bed occupanc*) OR ((Bed utilization) OR Bed utilisation)) OR Patient throughput) OR Patient discharg*	115513
#21	Search Patient discharg*	27250

#20	Search Patient throughput	13630
#19	Search (Bed utilization) OR Bed utilisation	8469
#18	Search Bed occupanc*	2873
#17	Search Bed-block*	84
#16	Search Access block*	164
#15	Search Hospital access*	104
#14	Search Inpatients	46494
#13	Search Inpatient capacit*	51
#12	Search Hospital Bed Capacity	24400
#11	Search (((Patient Transfer/organization & administration*) OR Patient transfer*) OR Patient flow logistic) OR Patient flow logistics	19369
#10	Search Patient flow logistics	8607
#9	Search Patient flow logistic	11246
#8	Search Patient transfer*	8276
#7	Search Patient Transfer/organization & administration*	1226
#6	Search (((patient flow) OR patient journey) OR patient care process) OR workflow	307774
#5	Search workflow	16118
#4	Search patient care process	84634
#3	Search patient journey	3578
#2	Search patient flow	206646
#1	Search (Hospitals) OR Hospital*	4382932
	Web of Science	
#	Searches	Records
# 10	#7 AND #6 AND #5 AND #4 AND #3 AND #2 AND #1 Refined by: PUBLICATION YEARS: (2018 OR 2014 OR 2010 OR 2006 OR 2017 OR 2013 OR 2009 OR 2005 OR 2016 OR 2012 OR 2008 OR 1999 OR 2015 OR 2011 OR 2007) AND DOCUMENT TYPES: (ARTICLE OR REVIEW OR CLINICAL TRIAL)	46
# 9	#7 AND #6 AND #5 AND #4 AND #3 AND #2 AND #1 Refined by: PUBLICATION YEARS: (2018 OR 2014 OR 2010 OR 2006 OR 2017 OR 2013 OR 2009 OR 2005 OR 2016 OR 2012 OR 2008 OR 1999 OR 2015 OR 2011 OR 2007)	47
# 8	#7 AND #6 AND #5 AND #4 AND #3 AND #2 AND #1	48
# 7	TOPIC: (Outcome Assessment) OR TOPIC: (Treatment Outcome) OR TOPIC: (Process performance) OR TOPIC: (key performance indicators) OR TOPIC: (Efficiency) OR TOPIC: (waiting times) OR TOPIC: (perioperative patient* delay) OR TOPIC: (patient* safety) OR TOPIC: (patient centered care)	5,002,089
# 6	TOPIC: (Patient throughput) OR TOPIC: (Patient Discharg*)	206,320
# 5	TOPIC: (Hospital Bed Capacity) OR TOPIC: (Inpatient Capacity) OR TOPIC: (Inpatient) OR TOPIC: (Hospital access*) OR TOPIC: (Access block*) OR TOPIC: (Bed-block*) OR TOPIC: (Bed utilization) OR TOPIC: (Bed utilisation)	264,885
# 4	TOPIC: (Patient Transfer*) OR TOPIC: (Patient flow logistic*) OR TOPIC: (Workflow)	226,508
# 3	TOPIC: (Patient Care Process)	200,862
# 2	TOPIC: (Patient Flow) OR TOPIC: (Patient Journey)	335,529
# 1	TOPIC: (Hospital*)	1,801,142
	Cochrane Library	
# 1	'"Patient Flow" in Title Abstract Keyword OR "Patient Journey" in Title Abstract Keyword OR "Bed Management" in Title Abstract Keyword AND "Hospital capacity management" in Title Abstract Keyword AND "outcome" in Title Abstract Keyword - (Word variations have been searched)': one result	1

2. Characteristic of included studies

First Author, Year of publication, Country, Study year(s), Journal	**Study Design**	**Setting**	**Number and type of patient**	**Method to improve**	**Intervention**	**Main Actors Involved in process redesign**	**Key results**
Alikhan, 2009, Canada Study year(s): 2008-2009 Healthcare Management Forum	Prospective pre-post study	ED	Not cited	Customized methodological framework embedding aspects of LEAN, Six-Sigma and Plan-Do-Study-Act methods	Institution of a Corporate Patient Flow Performance Team - Standardized performance indicators restitution at unit, service and program levels; - Admission/Discharge process improvement; - Daily proactive bed management; - Facilitating internal communication; - Using visual management tools	- External consultants - Top-Management - Middle-Management	- 83.1% decrease in emergent volumes waiting for greater than 24 hours; - 49.1% improvement in ED LOS for admitted patients; - no adverse outcomes on other key indicators
Amato-Vealey, 2012, USA Study year(s): - AORN Journal	Pre-post study	Operation Room, Intermediate Care Unit, Surgical Floors	Not cited	Six-sigma	Institution of a Core Group of employees of all involved areas - Discharge process improvement	- Front-line staff	- Percentage increase of intermediate care unit discharges before noon
Arya, 2013, USA Study year(s): 2010-2011 Academic Emergency Medicine	Retrospective pre-post study	ED	20.653 adults 20.215 controls	Not cited	Split Emergency Severity Index 3 (ESI 3) patient flow model	Not cited	- 5.9% decrease, from 2.58 to 2.43 hours, in the geometric mean of LOS for discharged patients; - Abdominal pain was the most common diagnostic grouping with a reduction in LOS of 12.9%, from 4.37 to 3.8 hours
Bhakta, 2013, USA Study year(s): 2009-2011 The journal of trauma and acute care surgery	Retrospective pre-post study	Trauma Intensive Care Units	262 adults 267 controls	Not cited	Implementation of trauma bed protocol in order to faster patient throughput within the ED and decrease trauma admissions to non-trauma ICUs	Not cited	Compared to the control phase: - ED LOS significantly decreased from 4.2 +/- 4.0 hours to 3.1 +/- 2.1 hours - a greater proportion of total patients were admitted to a designated ICU (93% vs 83%) - ICU readmissions were unchanged
Borestein, 2016, USA Study year(s): 2012-2013 Nursing Outlook	Cluster randomized controlled trial	General medical/surgery hospital units	792 adults 592 controls	Quality Improvement	Redesign of unit-based workflow and use of trained interprofessional team	Interprofessional leadership work-group (unspecified actors)	Among patient admitted to the intervention unit - Mean difference in observed vs. expected length of stay 1.03 days shorter - Incidence of complications and transfer to ICU lower - incidence of discharge to institutional care higher - no difference in mortality during hospitalisation

Brown, 2015, USA Study year(s): 2006-2010 Journal of Healthcare Quality	Retrospective pre-post study	ICU and OR	521 adults 1.036 controls	Not cited	Implementation of a coordinated patient transport system for patient's transfer from ICU to OR	Not cited	After implementation: - on-time OR start time deviations significantly lower - improvement in on-time OR starts - significantly reducing idle OR time
Castillo, 2011, USA Study year(s): 2006-2008 The Journal of Emergency Medicine	Retrospective pre-post study	ED	14.117 diversion hours 17.618 diversion hours control	Not cited	Implementation of best practice among collaborative Hospitals	- Project sponsor and project champions - External consultants - Top-Management	-Decrease of 19.9% of monthly average hours of diversion
Cha, 2009, South Korea Study year(s): 2006-2008 Academic Emergency Medicine	Prospective pre-post study	ED	45.583 adults, children 41.726 controls	Not cited	Implementation of an independent-capacity program which included the ability of emergency physicians to transfer admitted patients to surrounding area hospitals	Not cited	- Decrease of the mean ED LOS from 15.1 hours to 13.4 hours - Decrease of the mean LOS in the emergency ward from 4.5 days to 3.1 days - Decrease od the percentage of transfers to other hospitals from the ED from 3.5% to 2.5% - Increase of hospital mortality from 1.96 to 2.12, without clinical significance
Chadanga, 2012, USA Study year(s): 2008-2010 Journal of Hospital Medicine	Prospective pre-post study	ED	48.595 adults 50.469 controls	Toyota Lean for quality improvement - Rapid Improvement Event	Implementation of a Hospital Medicine ED Team	- Middle-Management (Hospital Medicine Service)	- Reduction of 27% of diversion due to medicine bed capacity - Reduction of 67% of patients transferred to a medicine floor and discharged within 8 hours - Increase of 61% in the number of discharges from the ED of admitted medicine - Boarded admitted patients were rounded upon 2 hours earlier by Team - Satisfaction among ED attendings was high
Chan, 2014, China Study year(s): 2011-2012 World Journal of Emergency Medicine	Prospective pre-post study	ED	281 adults 313 controls	Lean	A series of lean management work interventions to improve the admission and blood result waiting time	Not cited	- Significantly decrease of the triage waiting time and end waiting time for consultation - Decrease of the admission waiting time from 54.76 minutes to 24.45
Dickson, 2009, USA Study year(s): - Annals of Emergency Medicine	Prospective pre-post study	ED	Not cited	Lean	A series of lean management work interventions	Not cited	- Length of stay reduced in 3 of the EDs

Driscoll, 2015, USA Study year(s): 2012 Nursing administration quarterly	Pre-post study	Neuroscience service line (ICU, 2 general floors, post-anaesthesia recovery, rehabilitation unit)	Not cited	Lean/Six Sigma - Rapid improvement event	Intervention in order to decrease hospital internal diversions.	- Process improvement specialist - Middle-Management (Unit-based nursing managers and charge nurses, patient transport manager, housekeeping manager, case manager supervisor, bed manager)	- 50% decrease in the number of patients being internally diverted - Improved collaboration between units
Elder, 2015, Australia Study year(s): 2012-2013 Emergency Medicine Australasia	Retrospective cohort study	ED	8.932 adults and paediatrics 8.250 controls	Not cited	Incorporating a physician at triage (PAT) and implementation of a medical assessment unit (MAU)	Not cited	- ED LOS significantly decreased after PATplus MAU was implemented - Improvement in time to be seen by a clinician - Improvement in proportion of patients who did not wait -Increase in meeting 4-hour length of stay target
Elliott, 2015, USA Study year(s): 2010-2012 The Joint Commission Journal on Quality and Patient Safety	Retrospective interrupted time series analysis	ED, ICU	613 adults 1.088 controls	Quality improvement methods, including process mapping and LEAN principles	Implementation of an interdepartmental program designed to expedite the transition of care from the ED to the medical ICU	Interprofessional, multidepartmental task force (unspecified actors)	- Reduction of ED LOS by 30% (2.6 hours) from baseline - No significant differences in Medical ICU LOS , overall hospital LOS , or mortality
Evans, 2011, Canada Study year(s): 2007-2009 Healthcare Quarterly	Pre-post study	ED, ICU and Hospital Departments	Not cited	Adapted model of Plan-Do-Study-Act (PDSA) adding 'Define'. Lean / Six Sigma	- Leans tools - Operations research techniques - Bed Assignment Tool, Bed Mapping and Status communication Tool	Middle-Management (clinical managers, charge nurses, discharge planners, quality specialists) Front-line staff	Decrease in: - average time (h) from order to admit to depart ET - % of patient discharge or admit within 6 and 8 hours Decrease in: - % surgical cancellations due to no bed No change in: - Off-Service Rate (excluding ED days) - ICU occupancy rate
Fulbrook, 2017 Australia Study year(s): 2014 Australasian Emergency Nursing Journal	Prospective controlled trial	ED	19.773 adults	Not cited	Introduction of the nurse navigator role	Not cited	Slight improvement in National Emergency Access Target compliance with an average of 4.5 min per presentation saved. The labour cost associated with the time saved estimated to be $170,000.
Healy-Rodriguez, 2014, USA Study year(s): 2008-2009	Retrospective pre-post study	ED	14.832 adults and paediatrics 13.852	Not cited	Logistic Management Program	Not cited	Decrease in: - ED evaluation time (219 vs 207 minutes) - median ED placement time (193 vs 219 minutes - median inpatient length of stay (3.83 vs 3,93)

Journal of Emergency Nursing			controls				
Hendrich, 2004, USA Study year(s): 1997-2001 American Journal of Critical Care	Prospective pre-post study	Coronal Critical Unit and its step-down medical unit	Not cited	Evidence Based Design and Continuum Quality Improvement principles	Acuity-adaptable room	Front-line perspectives (Clinicians) Patients perspectives Expert on designing environments	Significant improvements in quality and operational cost: - a large reduction in clinician handoffs and transfers; - reductions in medication error and patient fall indexes; - improvements in predictive indicators of patients' satisfaction; - decrease in budgeted nursing hours per patient day - increased inpatients days per bed
Howell, 2010, USA Study year(s): 2005-2007 Journal of Critical Care	Retrospective pre-post study	ED, ICU and Coronary Care Unit	17.573 adults 16.148 controls	Not cited	Active bed management	Not cited	- Decrease in throughput from ED to coronary care unit and medical ICU by 99 minutes (254 vs 253 minutes) - Transfer rates and ICU death rates stable
Imperato, 2012, USA Study year(s): 2008 Internal and Emergency Medicine	Retrospective pre-post study	ED	9.011 adults 8.620 controls	Not cited	Physician in triage	Not cited	Reduction of: - the median time from registration to attending physician evaluation by 36 min - the median LOS for all patients was reduced by 12 min after the intervention - the number of patients who left without being seen from 1.5 to 1.3 %, but not statistically significant (p = 0.36) Decrease in: - the number of days on diversion (24 vs. 9 days) - total time on diversion (68 h 25 min vs. 26 h 7 min)
Jweinat, 2013, USA Study year(s): 2001-2012 Joint Commission Journal on Quality and Patient Safety	Prospective pre-post study	Hospital	Not cited	Lean	Collaborative quality improvement journey	- Top-Management - Middle-Management - External consultants	- Adult ED LOS reduction from 5.30 to 4.95 hours (until 2012) - 84% improvement in discharges by 11:00 A.M. - Decrease in LOS from 5.23 to 5.05
Lovett, 2014, USA Study year(s): 2010-2013 American Journal of Medical Quality	Prospective pre-post study	Hospital	Not cited	Not cited	Single, centralized Patient Flow Management Center (control of bed management across 3 Campuses including service as case management, environmental service, patient transport, ambulance and helicopter dispatch)	- Top-Management - External consultants	Improvements in: - ED walkouts - ambulance diversion Reduction in: - lost transfers - time to bed assignment - bed turnover time
Mumma, 2014, USA Study year(s): 2009-2011 Academic Emergency Medicine	Retrospective pre-post cohort study	ED	42.896 adults 48.358 controls	Not cited	Expansion of ED from 33 to 53 adults bed	Not cited	After expansion: - % of patient left without being treated is unchanged - total ED boarding time increase from 160 to 180 hours/day
Muntlin Athlin, 2013, Sweden Study year(s): 2010 Scandinavian	Prospective non-randomized cohort study	ED	1.838 adults 724 controls	Mixed-method design: ABAB phases first used where A was the	Introduction of multi-professional teams by reorganization of the work process. Each team, consisted of one physician, one Registered	Not cited	Compared to the control phase, at the last follow-up: - the median time to physician was significantly decreased by 11 minutes - the total visit time was significantly shorter (39 minutes shorter

Journal of Trauma, Resuscitation and Emergency Medicine				control phase (standard procedure) and B was the intervention phase + three follow-up phases (5-11-16 months)	Nurse (RN) and one Assistant Nurse (AN)		on average) - the 4-hour target was met in 71% compared to 59%
Odom, 2018, USA Study year(s): 2016-2018 Nursing Informatics	Prospective pre-post study	Hospital	Not cited	Data-driven Approach	A set of hospital-wide interventions implemented in order to reduce ED LOS	- Top-Management - Middle-Management - First-Line staff	ED LWBS dropped from 4% down to 3.4% ED LOS remained consistent year over year The physician admission order to inpatient bed assignment improved by over 30 minutes.
O'Connel, 2008, Australia Study year(s): 2004-2007 The Medical Journal of Australia	Pre-post study	ED	1.8 million attendances	Not cited	Clinical Service Redesign Program	Not cited	Implementation of: - % of patients admitted through the ED who egress within 8 hours - % of patients in triage category 3 whose treatment is commenced within 30 minutes of arrival - % of patients moved off an ambulance stretcher in to an ED bed within 30 minutes of arrival
Ortiga, 2012, Spain Study year(s): 2007-2009 BMC Health Service Research	Cross-sectional pre-post study	Hospital	28.577 adults 27.784 controls	Lean	A set of hospital-wide interventions implemented in order to standardize the admission and discharge processes	- Top-Management - Middle-Management - First-Line staff (clinicians) - Patient/Families	- Decrease in the median patients' global LOS from 8.56 days to 7.93 days - Increase in % of patients admitted the same day of the surgery from 64.87% to 86.01% - Increase of the median number of planned discharges from 43.05% to 86.01% - Decrease of median number from 5 to 3 of ED patients waiting for an in-hospital bed at 8:00 am
Perry, 2010, New Zealand Study year(s): 2008-2009 ANZ Journal of Surgery	Prospective pre-post study	ED and Surgical Department	5.346 adults 3836 controls	Not cited	Dedicated surgical assessment and review area for acute general surgical patients	Not cited	LOS reduced in all patients from 2.58 to 2.04 days and in those who did not require surgery from 2.56 to 1.96 days
Richardson, 2017, Australia Study year(s): 2013-2015 Emergency Medicine Australasia	Prospective with historical control	ED, Hospital	30.984 adults and paediatrics 81.882 controls	Not cited	A set of hospital-wide interventions implemented in order to reduce ED crowding	- Top-Management - Middle-Management - First-Line staff	- 9.1% increase in presentations and 22.6% decrease in mean ED occupancy - ED LOS within 4 h improvement from 56.1% to 68.8% - Daily crowding with more than 10 inpatients improved from 6:34 to 0:29 - Did not wait improvement from 5.1 to 3.0%
Sánchez, 2018, Spain Study year(s): 2015-2016 International Journal for Quality in Health Care	Pre-post study	ED	12.704 adults 11727 controls	Lean	Application of lean thinking in triage acuity level-3 patients.	- Two people ED executive team certified lean practitioners -Front-line staff (doctors, nurses, nursing assistants, porters and	Significant reductions in: - process time of discharged (182 vs 160 min) and transferred to observation (186 vs 176 min) patients - length of stay (389 vs 329 min) - waiting time (71 vs 48 min) No significant differences in: - left without being seen rate (5.23% vs 4.95%), - 72-h revisit rate (3.41% vs 3.93%)

						administrative personnel)	- mortality rate (0.23% vs 0.15%).
Sheridan, 2017, Canada Study year(s): 2014 Healthcare quarterly	Before after study	Hospital	Not cited	Lean, PDSA	Engagement with primary care providers and clinical associates with the use of standard work To improve patient discharge process	- Front-line staff (primary care providers, clinical associates)	- The target of 80% of discharge summaries sent to primary care within 48-hours exceeded at > 93% - Reduction in hospital readmission rate
Soong, 2015, Canada Study year(s): 2010-2012 BMJ quality & safety	Retrospective pre-post study	ED and General Internal Medicine Department	3.373 adults 3.369 controls	Audit and feed-back method	Improvement Team to perform a set of interventions using education, goal setting and real-time performance feed-back to improve time to admission to patient referred to general internal medicine	Not cited	- Decrease in the mean time from consultation request to admission order entry from 321 to 229 minutes - Decrease of overall ED LOS for general internal patients from 1.022 to 963 minutes
Svirsky, 2013, USA Study year(s): 2011-2012 The Journal of Emergency Medicine	Prospective study with control group	ED	1.346 adults	Not cited	Resident-initiated advanced triage	Not cited	- Decrease in median ED LOS by 37 minutes - No difference in the proportion of patients who left prior to medical screening
Twanmoh, 2006, USA Study year(s): 2003-2004 Managed Care	Not cited	ED	Not cited	Not cited	A set of interventions implemented in order to improve ED input-throughput-output process	Top-Management	- Decrease in ambulance diversion hours - Decrease in ED LOS - Decrease in the mean time 'door to bed' - Decrease in the mean time 'door to visit'
Vermeulen, 2014, Canada Study year(s): 2007-2011 Annals of Emergency Medicine	Retrospective cohort pre-post study	ED	Programm sites vs Control sites	Lean	Regional ED process improvement program (pay-for-results): dedicated hospital improvement teams + one external lean coach	Top-Management Middle-Management (senior leaders, managers) Front-line staff External consultants	Decrease in: - ED LOS - Time to physician assessment - Left-without-being seen rates - 72-hour ED revisit rates
Williams, 2011, Canada Study year(s): 2006-2008 Canadian journal of surgery	Prospective pre-post study	Orthopaedic Surgery Center	3.209 adults	Not cited	Hospital program to augment existing provincial capacity for hip and knee replacement	Not cited	- Mean patient satisfaction score of 4.7 out of 5 - Complication rate of 4.4% - Mean operating room time of 1 hour and 45 minutes - Mean postoperative LOS of 3.4 days - Additional 16% capacity
Yancer, 2006, USA Study year(s): 2003-2005 Joint Commission Journal on Quality and Patient Safety	Pre-post study	Hospital	Not cited	Not cited	3 process improvement teams (front-line and leadership staff) to focus on discharge, throughput and ED admission	Middle-Management Front-line staff	- 72% of ambulance diversion hours reduction from 2.365 to 65 -Decrease in the average in-hospital LOS (from 3.87 to 3.61) - Decrease in the average ED LOS (by 25 minutes) - Improvement of ED patient satisfaction from a score of 3.96 to 4.11 (range, 1-5)
Zocchi, 2015, USA Study year(s): 2010-2012 Joint Commission	Prospective pre-post study	ED	Not cited	Plan-Do-Study-Act and other methods	Collaborative Quality Program to improve ED flow	Top-Management External consultants	Among hospitals demonstrating improvement, reduction in the average of - discharged LOS (by 26 minutes) - admitted LOS (by 36.5 minutes)

Journal on Quality and Patient Safety							- boarding time (by 20.9 minutes) Left without been seen rates decrease by 1.4 absolute percentage points