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THE IMPACT OF THE EMERGENCY DEPARTMENT CROWDING ON ACUTELY ILL PATIENT EXPERIENCE AND HOSPITAL PERFORMANCE

Beatriz Lucas de Almeida Nunes

Dissertation submitted as partial requirement for the conferral of Master in Business Administration

Supervisor:

Prof. Alexandra Marques Fernandes, Professora Auxiliar, ISCTE Business School, Department of Marketing, Strategy and Operations.

October 2020

BUSINESS
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Beatriz de Almeida Nunes

Abstract

Background*:* ED Crowding is stated as one of the biggest problems in healthcare services that is compromising the quality of care and the performance of EDs and raising problems for patients.

Objectives: to expand and provide an updated critical analysis of the findings of peer-reviewed research studies, exploring the impact of ED crowding on patient experience and hospital performance.

Methods: a systematic literature review was applied, and it includes English-language scientific articles and primary studies. Inclusion criteria: articles with crowding measure/scale identified and with sufficient scientific evidence to support its impact on one or both affected strands. Search terms: 'Emergency Department', 'ED', 'Emergency Room', 'Emergency Service', 'Crowding', 'Overcrowding', 'Patient Satisfaction', 'Patient Experience' and 'Hospital Performance'.

Results: all identified studies revealed an association between ED crowding and patient satisfaction and perceived quality of care. It was, also, identified an association between ED crowding and several KPIs, demonstrating that it has a negative impact on hospital productivity, quality and operational, logistic and financial performance.

Conclusions: Literature revealed that ED crowding contributed to a poor patient experience, once it had impact on several domains of healthcare system, such as: safety, efficiency, timeliness, patient-centred care delivery and patient's perceived quality of care and overall satisfaction.

In the future, it would be interesting to develop a primary study about this subject in Portugal, once ED crowding is point out as one of the biggest problems in the Portuguese healthcare sector and there is a lack of studies investigating the Portuguese reality on this matter.

Keywords: health management, crowding, emergency department, key performance indicators, acutely ill patient experience or patient satisfaction, hospital performance.

Resumo

Enquadramento: a sobrelotação do serviço de urgência é identificada como um dos maiores problemas na área da saúde, que está a comprometer a qualidade dos cuidados prestados e o desempenho dos Serviços de Urgência (SUs) e a prejudicar o doente agudo.

Objetivos: expandir e facultar uma análise crítica e atualizada de resultados encontrados na revisão da literatura dos artigos científicos, sobre o impacto da sobrelotação do serviço de urgência na experiência do doente agudo e no desempenho do hospital.

Metodologia: foi aplicada uma revisão sistemática da literatura, que inclui artigos científicos em inglês e estudos primários. Critérios de inclusão: artigos onde foi identificada um indicador de sobrelotação e com evidência científica suficiente que fundamente o impacto deste fenómeno numa ou nas duas vertentes afetadas. Termos de pesquisa: 'Serviço de Urgência', 'SU', 'Sobrelotação', 'Satisfação do Doente', 'Experiência do Doente', e 'Desempenho do Hospital'.

Resultados: todos os artigos incluídos na revisão sistemática da literatura revelaram que existe uma associação entre a sobrelotação do SU e a satisfação e perceção do doente sobre a qualidade de cuidados e vários indicadores de desempenho, demonstrando que esta tem um impacto negativo na qualidade, produtividade e desempenho do hospital.

Conclusão: esta revisão revelou que a sobrelotação do SU contribuí para que o doente tenha uma experiência pobre no SU, uma vez que tem impacto em vários domínios do sistema de saúde, tais como: segurança, eficiência, pontualidade, prestação de cuidados centrada no doente, satisfação geral e perceção que o doente tem da qualidade dos cuidados.

No futuro, seria interessante desenvolver um estudo primário sobre este tema em Portugal, uma vez que a sobrelotação do SU é apontada como um dos maiores problemas do sistema de saúde português e que existe uma escassez de estudos que investiguem a realidade portuguesa sobre esta matéria.

Palavras-chave: gestão de saúde, sobrelotação, serviço de urgência, indicadores de desempenho, experiência do doente agudo ou satisfação do doente agudo e desempenho do hospital.

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List of Abbreviations

AB – Access Block;
AMI - Acute Myocardial Infraction;
ATS - The Australian Triage Scale;
CT – Computed Tomography;
CTAS - The Canadian Triage and Acuity Scale;
DTDT – Door To Doctor Time;
ED – Emergency Department;
EDCS - Emergency Department Crowding Score;
EDOR - ED Occupancy Rate;
EDWIN - Emergency Department Work Index;
EDWS - Emergency Department Work Score;
ESI - The Emergency Severity Index;
GDP – Gross Domestic Product;
HAC - Hospital- acquired Condition;
HCAHPS - Hospital Consumer Assessment of Healthcare Providers and Systems;
HIS – Hospital Inpatient System;
ICU – Intense Care Unit;
IPLOS – Inpatient Length of Stay;
JBI – Joanna Briggs Institute;
KPI – Key Performance Indicators;
LOS – Length of Stay;
LWBS – Left Without Being Seen;
MTS - The Manchester Triage Scale;
NEDOCS - National Emergency Department Overcrowding Scale;
READI - Emergency Analysis of Demand Indicators scores;
SETS - The Swiss Emergency Triage Scale;
SONET - Severely overcrowded – overcrowded – not overcrowded estimation tool;
TTAS - The Taiwan Triage and Acuity Scale (TTAS)**;**

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1. Introduction

Healthcare sector is one of the largest industries worldwide and an important component of economic performance (Walshe and Smith, 2011). Health organizations are inserted in a political and social environment, in which their actions are highly visible and scrutinized. Hence, the leadership and management performances and processes can be just as crucial as their outcomes (Walshe and Smith, 2011).

From a social perspective, the efficiency of Emergency Departments (EDs) is essential, since timely and good services can reduce costs associated with patient hospitalization, can contribute to a better quality of care delivery to each citizen and most importantly, it can save lives (Manolitzas and Stylianou, 2018; Núñez et al., 2018; Asplin et al. 2003).

Key Performance Indicators (KPIs), that are used in hospitals, were established to provide a framework/tools to measure, monitor and evaluate healthcare services and the quality of care and, to improve the performance, where values and standards are considered (Khalifa et al., 2011).

Currently, the number of visits to EDs is increasing and this growth in demand for emergency care combined with tightening budgets, which generate a lack of sufficient resources, has led to the problem of ED crowding (Khalifa and Zabani, 2016; Asplin et al., 2003; NHS, 2020 [1]). There is a growing number of government and health professionals' reports expressing the need to solve the ''ED crowding problem'' (Pines et al., 2011).

Crowding has been considered a worldwide health problem, since it is the most common phenomenon in EDs across the world. Pines and Griffey (2015) defend that there is a link between some of the deaths in the emergency department with crowding, once some patients worsen their health status as a consequence of an increased waiting time in the ED.

Besides, it has not only an impact on the hospital itself, since it is negatively associated with timeliness and patient-centred care delivery, patient safety and satisfaction and hospital efficiency, which are quality domains of hospital performance (Núñez et al., 2018; Guttmann, 2011). As, it can also alter the outcomes and behavior of patients and performance of healthcare professionals (Núñez, et al., 2018; Guttmann, 2011; Chan, Cheung, Graham, & Rainer, 2015).

1 Portuguese National Health Service. 2020. *Serviços de Urgência*, available from: https://www.sns.gov.pt/monitorizacao-do-sns/servicos-de-urgencia/ [accessed 10 Jan, 2020].

In one hand, it harms the patient, once it leads to increased waiting times that in turn increase the patient length of stay (LOS). The LOS is directly related with prolonged pain and suffering and leads to patient dissatisfaction and an increased possibility of patients leaving without being seen (Manolitzas and Stylianou, 2018; Rondeau et al., 2005; Boyle et al., 2011).

In the other hand, it harms healthcare professionals, since it causes high stress levels and decreased morale and productivity. Plus, it contributes for miscommunication between medical staff, medical errors, delays in starting treatments, making adherence to recognized guidelines more difficult and for rushed and unpleasant treatment environments, convening in potentially poor patient outcomes (Núñez et al., 2018; Guttmann, 2011; Rondeau et al., 2005; Chan et al., 2015; Boyle et al., 2011).

Finally, a crowded emergency department creates problems beyond that department such as ambulances being unable to unload their patients. This reduces resilience and capacity to pre-hospitals to respond to calls (Boyle et al., 2011). All these ED crowding consequences imply a financial loss for the hospital (Núñez et al., 2018; Guttmann, 2011).

The inefficiency in the throughput process jeopardizes satisfaction and compromises patient's outcomes (Jarvis, 2016; Pines and Griffey, 2015). It has also been found to influence future ED choice, as well as the likelihood of recommending the ED to others, which will have a direct impact on hospital outcomes and profit (Natesan et al., 2019).

ED crowding is the most important issue in the healthcare sector, and it allows measurement, subsequent research and policy evaluation (Boyle et al., 2011). Although several studies have been performed on ED crowding, there is no standard measure of this matter, since all measurements have dynamic structures (Hwang et al., 2011). Also, crowding is a dynamic problem that can vary each hour or minute (Pines & Griffey, 2015). According to Moskop et al. (2009a) there is a lack of consensus on the terminology used to refer to it, on an operational definition to identify it, and on a system or scale to measure it (Ergin, 2010).

Most of the studies about ED crowding, identified on the literature, are focused on its impact on hospital performance (Moskop et al. 2009b; Jarvis, 2016; Manolitzas and Stylianou, 2018; Núñez, et al., 2018; Moskop et al. 2009a; Chan et al., 2015; Handel et al., 2010), bleaching its impact on patient satisfaction.

Even so, the majority of the studies considered ED crowding as the phenomenon that most contributes to patient dissatisfaction (Manolitzas and Stylianou, 2018; Núñez et al.,

2018; Asplin et al. 2003), being that only few tested the real impact of it on patient satisfaction (Wang et al., 2017; Pines et al., 2008; Polónia et al. 2020), highlighting the lack of investment on this research area.

The way this dissertation adds value to the health management science insofar is taking into consideration the two strands affected by this phenomenon: ED performance and patients, which differentiate it from other studies.

Only by analyzing the associations between patient experience and ED crowding and the KPIs affected by it, is possible to find new developments on this research area and to create new and more effective strategies to improve the hospital performance (Welch et al., 2011).

The experience of the patient and the performance of the hospital have a positive relaionship (Manolitzas and Stylianou, 2018; Natesan et al., 2019), once the patient experience could be used as a qualitative indicator to measure the hospital performance and therefore to improve the ED healthcare services (Vanbrabant et al., 2019). All these facts stress the importance of being both included in such study.

The aim of this dissertation is to expand and provide an updated critical analysis of the findings of peer-reviewed research studies, exploring the impact of ED crowding on patient experience and hospital performance, by identifying indicators that measure the ED crowding or scales that score it and by assessing KPIs that measure the performance in ED. Thus, the research questions are:

- What are the indicators of ED crowding?
- What are the KPIs used in hospital to measure their performance in EDs?
- How does ED crowding have impact on the acutely ill patient experience in ED?
- How does ED Crowding have impact on the ED performance?

Hence, the specific objectives are:

- To identify indicators that measure ED crowding;
- To assess KPIs that measure the performance in ED;
- To analyze the impact of ED crowding on acutely ill patient experience;
- To analyze the impact of ED Crowding on hospital performance, measured by KPIs.

2. Literature Review

2.1. Healthcare Sector

In most developed countries, the healthcare sector covers from 8% to over 15% of the economy (Walshe and Smith, 2011). In 2013, the Portuguese healthcare expenditure covered 9.1% of the GDP, which 6,08% corresponded to the public health expenditure and 3.05% to the private health expenditure[2]. Thus, Healthcare sector is one of the largest industries worldwide and an important component of economic performance (Walshe and Smith, 2011).

Healthcare organizations are inserted in a political and social environment, in which their actions are highly visible and scrutinized, once almost everyone uses health services. Thus, the leadership and management performances and processes can be just as crucial as their outcomes (Walshe and Smith, 2011).

Globally speaking, the latest economic crisis exerted a massive pressure on public health systems, since there was a great shift of patients moving from the private health care providers to the public health care providers, especially those with low income (Manolitzas and Stylianou, 2018). Although most of the healthcare services are organized around the public health sector, since the beginning of this century this is progressively changing. Given that patients are more health-conscious and demanding, the private sector has begun to grow. This leaded to supply increase, which turn into a greater power of choice for patients (Eiriz and Figueiredo, 2005).

Healthcare systems contain a high level of social interactions that are characterized by complexity and in particular at decision points. Therefore, problems associated with healthcare service delivery and managing patient flow are usually hard to define issues (Qin and Prybutok, 2012).

There are different forms of care provided by health professionals. In hospitals, some of them taking place in the ED. EDs constitute an important sector in the healthcare system (Qin and Prybutok, 2012).

2.2. Emergency Departments

The most visible and indispensable role of ED in the community is the treatment of seriously ill and injured patients (Asplin et al., 2003). EDs are the main entry point of hospitals, which offer non-stop healthcare services to patients with different needs

2 *Administração Central do Sistema de Saúde* [ACSS]. 2017. Ministério da saúde: Relatório e contas 2016. Available from: http://www.acss.min-saude.pt/wp-content/uploads/2016/10/Relatorio-e-Contas-MS-2016.pdf [accessed 30 Oct, 2019].

(Vanbrabant et al., 2019). The ED is "*a complex system due to its unpredictability in patient arrivals, in service times of care and in human decision-making"* (Kaushal, 2015: 19).

ED is an important component of the healthcare system with several unique characteristics, such as:

- Most of patients arrive in need of urgent medical treatment without a scheduled appointment, which means that there is less control over the timing of patients' visits;
- It offers easy access to medical care and provides rapid access to an interdisciplinary medical team, ensuring an accurate diagnosis and an appropriate treatment;
- Patients do not need to be registered, which indicates that EDs have a large group of potential patients, leading to a large variation in patients' ages, backgrounds, illnesses, injuries, and mental statuses. The need for immediate care and the variety of presenting patient illnesses demand a greater emphasis on communication and ED provider expertise;
- Due to the complexity of patient illnesses, and the inability to predict the range of medical problems that will present, EDs facilities need to offer a broad range of treatment interventions. As a result of the potential diversity of medical issues, an ED professional must have a range of medical equipment available;
- The monetary cost of emergency department visits is higher compared with other departments (Qin and Prybutok 2012).

These unique characteristics can have an influence on how patients perceive the medical services that they have received, and the way that they make behavioural decisions (Qin and Prybutok 2012).

The Portuguese Health Ministry defined ED as a multidisciplinary and multi-professional service that aims to deliver healthcare in situations framed under the definition of emergency. Emergency are all situations where patient needs timely medical care, since its life or organic function are at risk. Portuguese EDs should cover three performance levels that differ according to their specific medical skills and technical requirements (human and material):

- Level one: the multipurpose emergency department that is in a central hospital with differentiated care and more valences and specialties;

- Level two: the medical-surgical emergency department that strategically located in an area that comprise a large number of inhabitants, so that way the distance between the local and the hospital will not be greater than 60 minutes in case of accident or illness;
- Level three: basic emergency department, which access is superior than 60 minutes (Health Ministry, 2014)[3].

In ED, patients can attend without prior appointment as mentioned above, which also means some patients must wait to receive care. Patient recommended waiting time in an ED is determined by their triage assessment, which is the initial process where health professionals evaluate patient health status (Ganley & Gloster, 2011; Kaushal et al., 2015).

Triage Process

Prioritization for treatment in the ED entails the more critically ill or injured receiving treatment first, so that patients with more acute needs are given more immediate care than those who are in less urgent need of medical attention.

This is a dynamic process once the health condition of patients can quickly change, allowing to rapidly identify high-risk patients upon arrival and to put the right patient, in the right place in the optimal timeframe. Thus, triage is a risk management system used to control patient flow when demand exceed service capacity (Ganley & Gloster, 2011).

There are many different triage systems: The Emergency Severity Index (ESI); The Canadian Triage and Acuity Scale (CTAS); The Australian Triage Scale (ATS); The Swiss Emergency Triage Scale (SETS); The Manchester Triage Scale (MTS); Taiwan Triage and Acuity Scale (TTAS), that differ between country/region (Oliveira et al., 2018; Hinson et al., 2018).

According to *Direção Geral da Saúde*[4],the MTS was developed and implemented in Manchester (UK) in 1997 and is the most used system across the world. It was implemented in Portuguese EDs in 2000 as an instrument for managing the clinical risk. (DGS, 2015). It allows to identify a clinical priority, patient severity criteria and the patient allocation to a more proper area in the ED. Patients are assessed by a nurse who will assign a score to the patient concerns, symptoms and signs, using a decision flowchart (with 52 possible situations) and will attribute 1 of the 5 categories with the name,

3 Portuguese Health Ministry. 2014. *Despacho n.o* 10319/2014. Lisbon. Available from: https://dre.pt/pesquisa/-/search/55606457/details/normal?p_p_auth=fhLc2GFn [accessed 30 Oct, 2019].
4 *Norma da DGS n.º 002/2015 de 06/03/2015,* updated in 23/10/2015. Available from: http://tempos.min-saude.pt/#/info, [accessed 4 Feb, 2020].

number, colour and time recommended until the first medical observation as shown in Figure 2.2.1..

Level	Nomenclature	Color	Waiting time in minutes
1	Immediate	Red	0 minutes, patients with life-threatening condition. In need of immediate attention.
2	Critical	Orange	10 minutes, patients that can develop into life-threatening situations if they are kept waiting or are having extreme pain. In need of attention in a relatively short period of time.
3	Urgent	Yellow	60 minutes, patients who have a medical condition but can wait some time before treatment without medical risk.
4	Standard	Green	120 minutes, patients who are able to wait while others with more critical needs go before them in priority. No medical risk in waiting.
5	Non-emergency	Blue	240 minutes, patients that have symptoms of illness but are not in immediate medical need of attention.

Figure 2.2.1. Nomenclature and waiting time in the ED according to MTS. (Adapted from Ganley and Gloster, 2011)

In this way, the MTS is a crucial tool since it ensures an appropriate and timely treatment for patients, thus guaranteeing better practices and the reduction of possible adverse effects for the patient (Ganley and Gloster, 2011).

Many countries such as Portugal adapted the MTS. In addition to the 5 categories presented in it, there is another that is identified by the white colour and it represents all situations considered "without criterion", being used in cases considered as "not serious" to be attended at the ED (Portuguese NHS, 2020)[5].

To summarize, EDs are complex systems due to its unpredictability, that have different processes, stages of patient flow and management risk systems (e.g. triage process), comparing to other departments.

Currently, the number of visits to EDs is increasing and this growth in demand for emergency care combined with tightening budgets, which generate a lack of sufficient resources, has led to the problem of ED crowding (Khalifa and Zabani, 2016; Asplin et al., 2003; NHS, 2020[6]).

5 Portuguese National Health Service (NHS). 2020. *Serviços de Urgência*, available from: https://www.sns.gov.pt/monitorizacao-do-sns/servicos-de-urgencia/ [accessed 10 Jan, 2020].
6 Portuguese National Health Service. 2020. *Serviços de Urgência*, available from: https://www.sns.gov.pt/monitorizacao-do-sns/servicos-de-urgencia/ [accessed 10 Jan, 2020].

2.3. Emergency Department Crowding

To Moskop et al. (2009a) the appropriate term to refer to the situation in a full or overloaded ED is “Crowding” or “Overcrowding” in which “overcrowding” suggests a more extreme situation, however this last term should be abandoned, as any crowding is harmful (Moskop et al., 2009a).

ED crowding is a phenomenon in which demand for services exceeds the ability to provide care within a reasonable time, compromising the performance of health professionals, specially to provide quality healthcare (Jarvis, 2016; Manolitzas and Stylianou, 2018; Núñez, et al., 2018; Moskop et al. 2009a).

Asplin et al. define crowding as a supply-side issue, suggesting it is “*a situation in which the identified need for emergency services outstrips available resources in the ED*” (Asplin et al., 2003: 174).

ED crowding is not a constant phenomenon, but a cyclic one, which means that at certain times of the day, week or year there are not enough resources to care for new ED patients (Handel et al., 2010).

Crowding has been considered a global health problem, since it is the most common phenomenon in EDs across the world (Núñez, et al., 2018; Guttmann, 2011; Chan, Cheung, Graham, & Rainer, 2015) and there is a growing number of government and health professionals’ reports expressing the need to solve the ‘‘ED crowding problem’’ (Pines et al., 2011). There are some authors defending that the growth of mortality rates associated with ED crowding suggest crowding should be considered a public health issue (Jarvis, 2016).

2.3.1. ED Crowding Causes

The reason for the growing crisis of ED crowding is multifactorial and can be explained using the Input-Throughput-Output Model developed by Asplin et al., (2003). This model applies operations management concepts to patient flow amongst ED.

ED Crowding causes can be divided in three components: the input, the throughput and the output component.

The Input component of the model refers to any event that contributes to the demand for ED services and the ability of the ED to cope with inflow of patients. There are three factors that affect ED coping with inflow of patients, identified in literature: the high volume of low-acuity patients, the limited access to primary healthcare contrasting the

availability of ED services 24 hours a day, 7 days a week and the increased volume in certain periods [e.g. winter], (Morley et al., 2018; Núñez, et al. 2018; Barros et al., 2012).

The Throughput component refers to factors related to ED efficiency, workload and capacity in assessing or treating patients already in the ED (Asplin et al. 2003).

Several factors affect throughput times, including the inability to efficiently triage large numbers of patients presenting to the ED, cohesiveness of patient care teams, the physical layout of the ED, nurse and physician staffing ratios, efficiency and use of diagnostic testing, accessibility of medical information, quality of documentation and communication systems and availability of timely treatment (Núñez et al., 2018).

The output component measures the efficiency and capacity of the Hospital Inpatient System (HIS) to move ED admitted patients once their treatment has been completed to inpatient hospital beds of the ambulatory care system or to provide timely care after discharge to outpatients (Asplin et al., 2003).

Delays in disposition decisions (admission of patients to hospital inpatient areas from EDs or discharge), also referred to as Access Block (AB), are pointed out as the biggest cause of ED Crowding (Ospina et al. 2007; Handel et al., 2010; Pines et al., 2011 and Chan et al., 2015). Many factors contribute to AB namely: the lack of physical inpatient beds; the lack of inpatient bed availability due to inadequate nurse to patient staffing ratios; delays in receiving test results; isolation precautions or delays in cleaning rooms after patient discharge; inefficient diagnostic and auxiliary services on inpatient units and delays in discharging hospitalized patients to post–acute care facilities (Asplin et al. 2003; Núñez, et al. 2018).

When investigating the causes of ED crowding it is possible to conclude that researchers initially focused on the factors that affect the input component such as use of the ED for non-emergency complaints or an ‘inappropriate’ use of ED (McCabe, 2001). More recent research, however, suggests that these factors are not the main cause of the problem, but AB is (Núñez et al., 2018, Chan et al., 2015, Pines et al., 2011 Handel et al., 2010, Moskop et al. 2009a and Ospina et al. 2007).

ED crowding is considered the most concerning issue in the healthcare sector, and it is a dynamic problem that can vary each hour or minute (Pines & Griffey, 2015), hence it allows measurement, subsequent research and policy evaluation (Boyle et al., 2011).

Although several studies have been performed on ED crowding, there is a lack of consensus on the terminology used to refer to it, on an operational definition to identify it and on a system or scale to measure it (Moskop et al., 2009a), since all measurements

have dynamic structures and each ED uses the one that is more adapted to its context/country (Hwang et al., 2011).

2.3.2. ED Crowding Scales and Indicators

The components of quantitative crowding scoring system are included in the input-throughput-output model and the objective of all scales is to measure crowding that can be used in real-time and integrated with clinical information systems (Ergin, 2010).

As there is a lack of consensus on a system or scale to measure it, it is important to summarize the different studies present in literature and analyze each method used by the different authors.

For Ospina et al., the percentage of the ED occupied by inpatients (output component) is the most significant indicator pointed out, the total ED patients (input component) of crowding and patient LOS (throughput component) are the second and third most relevant indicator, respectively (Ospina et al. 2007).

To Gabayan et al. the two measures of ED crowding are the patient transit level and the ED system level. Patient transit level includes: DTDT; treatment time (the time from first physician assignment until the order to discharge) and the total LOS.

The ED system level includes: Occupancy at entry (the number of patients in the ED at patient's registration) and the time-averaged occupancy (the number of patients in the ED during patient's visit); LOS at entry and the time-averaged LOS and boarding time at entry and the time-averaged boarding time (which is defined as the time interval between an order to admit is placed to the time a patient left the ED or arrived at the inpatient ward, Gabayan et al. 2015).

Boyle et al. (2011) compared 6 crowding scales in the literature: Real-time Emergency Analysis of Demand Indicators scores (READI), Emergency Department Work Index (EDWIN), Emergency Department Crowding Score (EDCS), National Emergency Department Overcrowding Scale (NEDOCS), Emergency Department Work Score (EDWS) and ED Occupancy Rate (EDOR) or Level (multiplied by 100%), as shown in Table 2.3.2.1.

Table 2.3.2.1. ED crowding scales (Adapted from Boyle et al., 2011)

Scale	Indicators	Score	Conclusion
READI	Demand Value = (Bed Ratio + Provider Ratio) x Acuity Ratio	DV greater than 7 indicates crowding.	There is a poor agreement between READI score and staff perception of

			crowding.
EDWIN	EDWIN = sum of the number of patients presented in the ED x the triage category (1-5)/ number of physicians on duty x (number of beds available – number of admitted boarders).	EDWIN score less than 1.5 suggest an active but manageable ED, between 1.5 and 2 a busy ED and greater than 2 a crowded ED.	This scale correlates well with staff perception of crowding and is a strong predictor of ambulance diversion.
EDCS	Calculations of this scale are unclear, there are only inputs to it such as: - the number of physicians on duty; - the number of staffed ED beds; - the number of critical care patients; - the number of total ED patients; - the number of staffed hospital beds; - the hospital occupancy rate.	EDCS is a score between 0 and 100.	It is a strong predictor of the number of patients who Left Without Been Seen (LWBS - which is percentage of the patients who leave the ED before being seen by a health professional);
NEDOCS	- the total number of ED patients and the number of ED beds; - the total admitted patients in ED and the number of hospital beds; - the number of patients using ventilators and the longest patient boarding time; - the time from arrival to bed of the last patient assigned to a bed.	It is generated a score between 0 and 200, using these indicators.	This scale is a good predictor of the number of patients who LWBS, is highly correlated with the perception of crowding by health professionals.
EDWS	- the number of waiting patients in association with the number of available beds; - the number of patients presented in ED in each triage category with the number of nurses on duty; - the number of admitted		This scale is used only in EDs where the triage system used is Emergency Severity Index;

	patients with the number of beds available.		
EDOR	EDOR = total number of patients in ED at any point regardless of any throughput process after registration / total number of licensed treatment bays (observations units and fast tracks but excludes hallway locations).	EDOR above 1.0 indicates there are more patients than ED treatment spaces. Uses 1hour measurement interval.	Considered easy to calculate, can be used in real-time situations and is significantly associated with the healthcare professionals' perception of crowding and quality of care (Sion Jo et al. 2014, Verelst et al. 2015, Boyle et al. 2011, McCarthy et al., 2008, Hoot et al, 2007).

Boyle et al. (2011) argue that many of these six scales that mainly aim to quantify crowding are limited by being country specific or lack a standard in development and are incompletely validated.

That is why some of these authors have previously developed an eight-point operational definition of crowding, also following the Input-throughput-output model structure, and with measures of ED crowding that can be grouped into two separated perspectives: the patient's and the ED's as shown in Table 2.3.2.2..

Table 2.3.2.2. Eight-point operational definition and measures of ED crowding. (Adapted from Beniuk et al., 2012)

Perspective	Measures of ED crowding	Score
Patient	Time until triage (input measure)	Crowded: delay greater than 5 minutes from the time of patient arrival to the beginning of their initial triage.
	Patients' total LOS (throughput measure)	Crowded: the 90th percentile of patients LOS is greater than 4 hours.
	Doctor-To-Door-Time (DTDT) (throughput measure)	Crowded: emergent patient waits longer than the time recommended in MTS according to the type of priority attributed in the triage process.
	ED boarding time (output measure)	Crowded: less than 90% of patients have left the ED 2 hours after the admission decision.

ED	The ability of ambulance to offload (input measure)	Crowded: 90th percentile time between ambulance arrival and offload is greater than 15 minutes.
	Patients who LWBS or treated (input measure)	Crowded: the number of patients LWBS is greater than or equal to 5%.
	ED Occupancy Rate (throughput measure)	Crowded: rate is greater than 100%.
	The number of patients boarding - admitted patients waiting to be placed in an inpatient bed (output measure)	Crowded: the occupancy of boarders in the ED is greater than 10%.

To Boyle et al. (2011) only counting the number of patients who leave before treatment is simple but ignores the complexity of crowding.

To Morley et al. (2018), the most commonly accepted crowding scales are EDWIN, NEDOCS and EDOR and the most commonly accepted metrics of crowding are: LOS; LWBS; hours of ambulance diversion; hours of AB; recommended waiting time according to the attributed priority in triage and timed patient disposition targets (targets for the time patients spend in ED: e.g. in 2004 England set a 4-hour target).

To Wang et al. (2017) the best scales to measure ED Crowding are NEDOCS and SONET (Severely overcrowded – overcrowded – not overcrowded estimation tool: Score =24.5×total patient index+58.1×waiting room patient index+2.7×number of results pending for patients+12.2×the longest time in hours of patient in the waiting room+32.4) not crowded ≤100, crowded >100 to ≤140 and severely crowded >140).

To Pines et al. (2008) measures of crowding, such as EDWIN and NEDOCS are less predictive of ED performance and outcomes, once they are much more difficult to calculate than other indicators.

In summary, the LOS and EDOR are the most commonly used measures of crowding (Bergs et al., 2019, Morley et al., 2018, Boyle et al., 2011).

When investigating ED crowding indicators, it is possible to conclude that most of authors considered EDOR to be the most accurate method for measuring ED crowding and to be the simplest and overall best indicator, once it is easy to calculate, can be used in real-time situations and is significantly associated with the healthcare professionals' perception of crowding and quality of care (Hoot et al, 2007; McCarthy et al., 2008, Boyle et al. 2011) and, also because overcapacity can be define as "*having more patients than treatment spaces in the ED*" (Welch et al., 2011: 36).

2.3.3. ED Crowding Impact

ED Crowding is pointed out as one of the biggest problems in healthcare services that is compromising the quality of care and the performance of EDs (Mchugh et al. 2011[7]). It harms the operational, logistic, economic and financial performances of the hospital (Núñez et al., 2018; Guttmann, 2011). It has system effects, but it also raises problems for patients and health professionals.

The system effects are increased Inpatient LOS (IPLOS) and increased ED LOS, since it causes delays in every stage of the ED visit, from initial assessment (registration and triage processes) to treatment to final decision making to admission or discharge (Núñez et al., 2018; Chan et al., 2015; Guttmann, 2011and Moskop et al. 2009a). There are some studies that have shown that overall hospital occupancy rates are strongly correlated with the LOS of patients in the ED (Beniuk et al., 2012, Moskop et al. 2009a).

The effects of ED crowding on patient are poor patient outcomes, increased mortality in the critically ill, delayed assessment and care, which cause prolonged pain and suffering, increased IPLOS, risk of unplanned readmission, reduced patient satisfaction, exposure to error, higher costs for inpatients and LWBS (Wiser et al., 2015; Moskop et al. 2009a, Chan et al., 2015; Handel et al., 2010; Manolitzas et al. 2018; Rondeau et al., 2005; Boyle et al., 2011).

For patients, the frustration with long waits can cause up to 10% of LWBS and these patients are exposed to a safety risk (Guttmann, 2011).

ED Crowding causes a reduction in the patient's safety, privacy, confidentiality, dignity and completeness of care, it creates delays, more barriers in the participation in the decision-making process for treatment and decreased quality in healthcare delivery. All these factors compromise the patient's trust in the ED (Moskop, et al. 2009b; Mchugh et al. 2011).

Finally, the staff effects are non-adherence to best practice guidelines, increased staff stress, increased violence towards staff, decreased productivity, miscommunication between medical staff and more medical errors, once it can change health professionals' routines and decision making process and contributes to a rushed and unpleasant

7 Mchugh, M., Dyke, K. Van, McClelland, M., & Moss, D. 2011. *Improving Patient Flow Department Crowding : and Reducing Emergency Department Crowding : A Guide for Hospitals*. **Agency for Healthcare research and quality**. AHRQ Publication No.11(12)-0094. Available from: http://hsrc.himmelfarb.gwu.edu/sphhs_policy_facpubs [accessed 4 Feb].

treatment environment (Núñez et al., 2018; Chan et al., 2015; Guttmann, 2011; Boyle et al., 2011 Moskop et al. 2009a; Rondeau et al., 2005).

Most of the studies about ED Crowding and its impact on patient, identified on the literature, considered ED crowding as the phenomenon that most contributes to patient dissatisfaction (Manolitzas et al., 2018; Núñez et al., 2018; Asplin et al. 2003).

2.4. Experience of the Acutely Ill Patient

Acutely ill patients are those who have any severe injury, episode of illness or an urgent medical condition, that lasts a relatively short period (often less than a month) and requires short-term treatment, usually they need emergent medical care and seek an ED (Dahlen et al., 2012).

Most of the patients that seek medical care in an ED are acutely ill and in need for emergent medical treatment without a scheduled appointment (Dahlen et al., 2012).

Upon arrival at the ED walk-in patients should move through stages of care on the healthcare facility. This movement is called patient flow (Kaushal et al., 2015).

2.4.1. Patient Flow

The patient journey from arrival to exit can be divided into 3 phases: the waiting for treatment phase, which is constituted by the registration - patient demographics are captured accurately for billing and record keeping purposes, the triage process and waiting for physician consultation; the treatment and post-treatment phase, (Kaushal et al., 2015).

Another model where the patient flow is represented is the Input-Throughput-Output Model, described previously. The different steps the patient follows amongst ED are divided into the three components of the model. The input component refers to the arrival time, in the throughput component there is the registration phase, the triage process, the bed assignment or waiting for physician consultation (depending on the ED/country), the consultation with the physician and then examinations and treatment phase or treatment and examinations (depending on patient health status). And finally, there is the admission or discharge corresponding to the output component of the model (Vanbrabant et al., 2019), as the Figure 2.4.1.1. shows below.

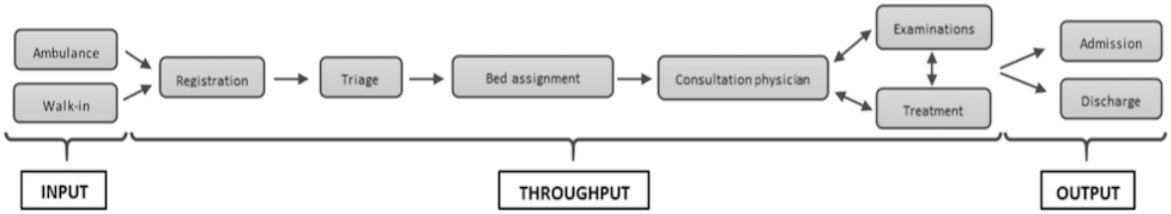

Figure 2.4.1.1. General patient flow through an ED according to the Input-Throughput-Output Model. (Adapted from Vanbrabant et al., 2019).

2.4.2. Patient Experience

Acutely ill patient experience involves the range of interactions that patients have with the healthcare system, including their care from health plans and health professionals in hospitals or in other healthcare facilities that influence patient perception across the continuum of care. Patient experience is an integral component of healthcare quality indicator, alongside providing clinical excellence and safer care.

There are three dimensions of patient experience: the physiologic illness experience (e.g. bleeding), customer service and the lived experience of the illness (Wolf et al. 2014).

Patient experience is affected by several aspects of healthcare delivery that patients value such as autonomy (involvement in treatment decisions), choice (of provider and access to service - non-discriminatory, physical, economic and access to information), communication (access to records and medical communication), professionalism, technical quality, efficiency, confidentiality, dignity, prompt attention (timeliness and availability of health professionals when needed), quality of basic amenities (food, physical environment, hygiene, cleanliness and hand-washing) and overall satisfaction (Wolf et al. 2014 and Polónia et al. 2020).

From the patient perspective, satisfaction is influenced by all interactions with health professionals, communication and delivery of information and the perceived waiting times (Polónia et al. 2020). According to Qin et al. (2013) the dimensions of accessibility, efficiency, interaction, professionalism, tangibility and technical quality are positively related with quality of service, emotions, perceived value, expectations of satisfaction, image of the institution, waiting time and patient recovery. Qin et al. (2013) realized patient satisfaction has a positive effect on patient loyalty.

2.4.3. Patient Satisfaction

Patient satisfaction is widely discussed in the healthcare industry. It has become part of its growth strategies. Patient Satisfaction is influenced by patient's emotions and expectations and the economic value attributed to the service and these factors will

influence the future behavioural intensions of each patient namely its loyalty to the service or to health professionals. Waiting time is also a variable as it influences emotions and treatment adherence (Polónia et al., 2020).

Polónia et al. (2020) designed and applied a conceptual model specific to hospital emergency departments (Appendix A). It combined essential dimensions for the assessment of patient satisfaction in this context. The dimensions were divided in three different groups.

The first group contained five dimensions that enable the patient to perceived quality of the service provided (Tangibility – accessibility to medical care and update clinical equipment; efficiency; professionalism; technical quality and communication). The second group contained the perceived quality and five more dimensions that precede the patient satisfaction (Waiting Time; Perceived Value; Emotions; Fairness and Satisfaction Expectations). And the third group contained the patient loyalty dimension that results from Patient Satisfaction (Polónia et al., 2020).

These authors concluded that the perceived quality of service and fairness have a positive effect on patient satisfaction, patient satisfaction has a positive effect on patient loyalty, and waiting time has a negative effect on patient satisfaction. Also, perceived value and satisfaction expectations influence patient satisfaction.

Patient Satisfaction and ED Crowding

Patients spend most of their time in the ED waiting due to the mismatch of healthcare resources and demand (Kaushal *et al.*, 2015) which is the major cause of patient dissatisfaction (Portuguese National Health System, 2010)[8].

Acutely ill patients having the longest waits are those who present with less urgent symptoms. The waiting time can be divided into two categories: the waiting time as perceived by the patient that could be experienced on a psychological or physiological level and the actual waiting time. Occupied time is perceived shorter than unoccupied. In addition to that, the pain, worry and uncertainty make the waiting time feel longer than it is (Dahlen et al., 2012).

According to Dahlen et al. (2012: 2) “Low priority patients may feel ignored, not in control of their situation or that they are not being taken seriously, due to the long waiting

8 Campos, L., Saturno, P., Carneiro, A. V. 2010. Plano Nacional de Saúde 2011-2016 – A Qualidade dos Cuidados e dos Serviços. Available from: http://1nj5ms2lli5hdggbe3mm7ms5.wpengine.netdna-cdn.com/files/2010/07/Q2.pdf, [accessed 10 Feb, 2020].

time in the ED sometimes disenable health professionals to provide information to patients about their situation timely". Regardless of their medical prioritization, acutely ill patients find nursing care more satisfying than those with less urgent needs.

The inefficiency in the throughput process jeopardizes patient satisfaction and it compromises patient's outcomes, once it causes delays in starting treatments, clinical error to occur (Jarvis, 2016; Pines and Griffey, 2015) and it has been shown "to affect their compliance with discharge instructions including medications usage, as well as follow up visits" (Natesan et al., 2019: 2). It has also been found to influence future ED choice as well as the likelihood of recommending the ED to others, which will have a direct impact on hospital outcomes and profit (Natesan et al., 2019).

Patient Satisfaction is a KPI used to measure the quality of care and the performance of EDs, once it describes how patients perceive and value healthcare (Soleimanpour et al., 2011). To improve quality of care it is necessary to narrow the gap between the patient's expectations and perceptions, thus increasing its satisfaction and loyalty. The most significant determinants of the quality of care in EDs are its accessibility, physical conditions, technical quality, the level of information provided, the knowledge and experience of health professionals and services and communication with patient and family (Polónia et al., 2020;Porter et al., 2010). With high level of quality, a high degree of satisfaction arises, which is an important determinant of loyalty and compliance with the health process.

Satisfied and dissatisfied patients make behavioural decisions differently. For instance, patients with higher levels of satisfaction are more likely to be compliant with health professional advice and to recommend the healthcare provider to their friends and relatives (Qin et al. 2013).

The experience of the patient and the performance of health professionals in the healthcare delivery are strongly associated (Manolitzas and Stylianou, 2018; Natesan et al., 2019), once they are dependent variables and the patient experience could be used as a qualitative indicator to measure the hospital performance and therefore to improve the ED healthcare services (Vanbrabant et al., 2019).

2.5. Hospital performance in ED

Regarding the hospital's performance in the delivery of healthcare, it is assessed/rated by government structures (e.g. Portuguese health system - ACSS monitors

the performance of EDs monthly[9]). A framework was put forth by the Institute of Medicine (IOM) in 2001. It is used internationally for performance and quality assessment and includes the following six domains of healthcare system:

- Safe (avoiding injuries to people for whom the care is intended);
- Effective (providing evidence-based healthcare services to those who need them);
- Patient-centred (providing care that responds to individual preferences needs and values);
- Timely (reducing waiting times and harmful delays for both patients and health professionals);
- Efficient (maximizing the benefit of available resources and avoiding waste);
- Equitable (providing care that does not vary in quality because of gender, ethnicity, geographic, location and socio-economic status).

In the Portuguese Health System, the improvement of information and knowledge is one of the governmental priorities, being relevant the availability of information about the performance of health institutions to monitor, evaluate and control the economic and financial performance of services ACSS (2020)[10].

In 2013, ACSS started by publishing benchmarking reports for hospitals about accessibility, quality, productivity and economical and financial performance. Recently proceeded to the monthly disclosure of information about activity, assistance performance and economical and financial performance of the National Health Service hospital institutions. This way the hospital performance is publicly reported.

According to Eiriz and Figueiredo (2005) it is important to define an evaluation tool to help organizations and customers to choose the best service. Therefore, instead of evaluating performance based on clinical or technical processes, the evaluation needs to be based on outcomes and indicators.

More recently healthcare managers and organizations' performances are under constant scrutiny. There is a constant stream of directives and guidance from government, national agencies, professional associations and others telling them what should or not

9 *Administração Central do Sistema de Saúde* [ACSS]. 2017. Hospital Benchmarking. Available from: https://benchmarking-acss.min-saude.pt/MH_Enquadramento/Objetivos, [accessed 2 Sep, 2020].
10 *Administração Central do Sistema de Saúde* [ACSS]. 2017. Hospital Benchmarking. Available from: https://benchmarking-acss.min-saude.pt/MH_Enquadramento/Objetivos, [accessed 2 Sep, 2020].

should be doing (Walshe et al. 2011).

Thus, governmental entities and hospitals developed and established KPIs, where values and standards are considered (Khalifa et al., 2011).

2.5.1. Key Performance Indicators

KPIs are management tools used to measure, monitor and evaluate the performance and success of an organization (Khalifa et al., 2011). KPIs show trends and strategies to plan and achieve improvements. KPIs can be classified into the three levels of performance in management: operational, tactical and strategic indicators (Khalifa et al., 2011).

Each category has its own methods of measurement, objectives and expected outcomes and can be related to one of the components of the healthcare system: structure (evaluate environment components where healthcare delivery takes place - material, human and organizational resources e. g. number of rooms); process (evaluate interaction between patient and healthcare professionals e.g. EDOR and LOS) and outcomes (effects of healthcare on patient health status e.g. patient satisfaction), (Thawesaengskulthai et al., 2015; Donabedian et al., 1980).

According to Khalifa and Zabani (2016), it is crucial to develop KPIs that are measurable and beneficial to performance management and improvement. KPIs should be adapted or disaggregated to fit in each country reality, organization (e.g. health KPIs), hospital and department (Núñez et al. 2018). Therefore, there are specific KPIs for EDs (ED KPIs), different from other hospital departments (Núñez et al. 2018).

ED KPIs are developed and adapted to each country and ED, hence each ED has its own method for KPIs' selection and performance evaluation goals (Núñez et al. 2018). There are several articles in literature discussing this subject and all have different perspectives and included different KPIs on their studies.

2.5.2. ED KPIs

The National Quality Forum (2008) in the United States has endorsed the use of annual rates of patients who LWBS and LOS in emergency departments as measures of efficiency, safety and timeliness[11]. A rate of LWBS above 5% is considered an indicator

11 The National Quality Forum (NQF). 2008. NFQ endorses measures to address care coordination and efficiency in hospital emergency departments. Available at: https://smhs.gwu.edu/urgentmatters/sites/urgentmatters/files/AR_NQF%20Press%20Release.pdf. [accessed 12 Feb, 2020].

of inefficient in the ED healthcare (Welch et al.,2011; Ergin et al., 2010; Hoot et al., 2007).

For Abo-Hamad and Arisha (2013) there are two main key performance areas: patient throughput and ED efficiency. The KPIs for patient throughput are the average waiting time and time-averaged LOS, while for ED efficiency they are ED productivity, resource utilization and layout efficiency.

Vanbrabant et al. (2019) classified KPIs in five different categories:

- Qualitative KPIs: Patient satisfaction and Patient safety;
- Time-related KPIs which are easier to measure and to access: LOS; DTDT and Boarding time;
- Proportion KPIs which describe the occurrence of ED crowding effects: Ambulance Diversion and LWBS.
- Utilization (ratio of active hours to total available hours of a resource- 100% weaken the quality of care) and Productivity KPIs: Personnel Utilization (time ED staff are busy); Equipment Utilization; Patient Throughput (number ED patients in comparison with the available resources e.g. Electrocardiograms performed per 100 patients seen); Travel time (distance health professionals have to travel in the ED during a shift); Degree of ED crowding; Average number of available beds; Patient Census (the number of patients simultaneously present in the ED).
- Budget-related KPIs

Khalifa et al. 2015 divided KPIs in 10 categories:

Seven are general KPIs of the hospital: Patient Access Indicators; Inpatient Utilization Indicators; Outpatient Utilization Indicators; OR Utilization Indicators; Generic Utilization Indicators; Infection Control Indicators – e.g. Hospital-Acquired Condition (HAC), healthcare associated infections and Documentation Compliance Indicators.

Three are ED KPIs:

- Patient Safety Indicators: unplanned readmission within 30 days of discharge, and unplanned transfer to any critical unit;
- ED Utilization Indicators: total number of ED visits, ED waiting time (DTDT), ED treatment time (Doctor to discharge), ED admission waiting time (boarding time) and percentage of patients LWBS;

- Patient Satisfaction Indicators: inpatient satisfaction rate and outpatient satisfaction rate.

For Kaushal et al. (2015) the patient waiting times, the LOS, the resource utilization, and the LWBS rate are main KPIs used in EDs.

For Ganley and Gloster (2011) in the triage process, by determining the number of patients in each category of the triage queue, it is possible to get a better understanding of the workload of an ED. To measure the effectiveness of the ward qualitatively, it is possible to compare the recommended maximum waiting times for each patient with the actual waiting times.

In the United Kingdom the college of Emergency Medicine and Royal College of nursing and the Department of Health worked closely together and developed a set of quality indicators designed to ensure focus on the ED performance (Heyworth, 2011), which are:

- service experience – feedback from Patients, staff and caregivers (included in the patient-centred IOM quality domain);
- LWBS (<5%);
- unplanned reattendances (rates below 5% reflect high quality);
- time to initial assessment (aim to occur within 15 minutes of the patient's arrival);
- time to treatment (patients should be seen by a decision maker within 60 minutes from arrival);
- total LOS (95^{th} percentile wait above four hours for admitted patients and no admitted is not good practice).

In Portugal, ACSS monitors the productivity and efficiency of EDs monthly, using performance indicators such as the total number of attendances, percentage of urgent attendances with hospitalization, percentage of attendances with green, blue or white priority, percentage of frequently users with more of 4 attendances and percentage of patients attended in the estimated time (ACSS, 2017). Besides, in Portugal each hospital has its own key performance indicators also evaluated monthly.

For example, Braga Hospital uses 10 indicators for the ED and for each indicator, there are reference values defined in the management contract that the hospital must comply with at the end of the year, under penalty of fines from regulating bodies (Silva, 2017).

The indicators and the reference values for 2013 were:

- rate of patients undergoing analgesia and sedation in ED – 15%;

- time-averaged between arrival and triage process – 12 minutes;
- time-averaged between triage process and the first medical observation – 63 minutes;
- rate of Patients that has a LOS more than 3 hours – 31%;
- rate of Patients that has a LOS more than 6 hours – 10%;
- time-averaged LOS – 165 minutes;
- time-averaged of length in the observation unit – 14 minutes;
- readmission rate in the ED until 24 hours – 3%;
- readmission rate in the ED until 72 hours with hospitalization - 1;
- rate of Patients LWBS – 3% (Silva, 2017).

Chan et al. (2015) argue that to relieve the crowding problem government entities elaborated KPIs for EDs. One of them was the UK 4-hour target. This makes the hospital administration more responsible for its performance and, more specifically, the AB and crowding. Despite the definition of those measures is a way to improve the quality in the delivery of healthcare, there were reported some situations where healthcare had been compromised. Therefore, the 4-hour target was replaced by performance indicators:

- No of patients LWBS;
- No of patients that returned to the ED;
- Waiting time until first medical observation;
- Waiting time until the treatment;
- LOS in ED (Chan *et al.*, 2015).

Qin et al. (2013) argue that patient satisfaction is the most useful indicator in providing information about structure and process and outcome of ED performance.

Eiriz and Figueiredo (2005) considered patients and providers' expectations and perceptions as the most important measures to evaluate healthcare quality.

To conclude, performance indicators are extremely important once they could be used to provide information and to facilitate organizational change (Khalifa et al., 2011). For this to occur it is necessary to institutionalize the evaluation by the government structures and the implementation of evaluation bodies capable of fostering information for decision making. The public policies should be followed by systematic evaluations, as institutional procedures, continuously adapting to the results and recommendations provided. This evaluation must be used to improve the performance of the health systems (ACSS, 2017).

3. Methodology

3.1. Research Context

ED crowding is the most important issue in the healthcare sector, and it allows measurement, subsequent research and policy evaluation (Boyle et al., 2011). Although several studies have been performed on ED crowding, there is no standard measure of ED crowding (Hwang et al., 2011, Ergin et al., 2010).

Most of the studies considered ED crowding as the phenomenon that most contributes to patient dissatisfaction (Manolitzas and Stylianou, 2018; Núñez et al., 2018; Asplin et al. 2003), being that only few tested the real impact of it on patient satisfaction (Wang et al., 2017; Pines et al., 2008; Polonia et al. 2020), highlighting the lack of investment on this research area.

The experience of the patient and the performance of the health professionals in healthcare delivery have a positive association (Manolitzas and Stylianou, 2018; Natesan et al., 2019).

Only by identifying on literature indicators that measure the ED crowding, assessing KPIs that measure ED performance and analyzing its impact on hospitals and patients, is possible to find new developments on this research area and to create new and more effective strategies to improve the hospital performance.

3.2. Data Collection instruments

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed (Appendix B), (Moher et al., 2009). A comprehensive search was performed in three electronic databases: Scopus, PubMed and Science Direct between May to June 2020.

Search and data extraction

Search terms used were: ‘Emergency Department’, ‘ED’, ‘Emergency Room’, ‘Emergency Service’, ‘Crowding’, ‘Overcrowding’, ‘Patient Satisfaction’, ‘Patient Experience’ and ‘Hospital Performance’. All these terms were validated in MeSH.

The complementary details of the search process were as follows: *Emergency Department* OR *ED* OR *Emergency Room* OR *Emergency Service* AND *Crowding* OR *Overcrowding* AND *Patient Satisfaction* OR *Patient Experience* AND *Hospital Performance.*

3.3. Research Design

A Systematic Literature Review was applied, and it includes articles that take into consideration one or both strands affected by this phenomenon: ED performance and patient experience.

Search Strategy

Inclusion criteria were: scientific articles (used a quantitative or qualitative research design) and primary studies (prospective or retrospective); written in the English, Portuguese and Spanish languages; published in peer-reviewed journals with the possibility of access to the original full-text article; articles were the crowding measure/scale that has scientific evidence was identified; articles with sufficient scientific evidence to support the impact of ED crowding on patient experience and/or hospital performance:

- ED crowding and patients experience: there were included articles where the impact of ED crowding on patient experience was tested e.g. standardize measure of patient satisfaction - inpatient satisfaction rate or outpatient satisfaction rate and a patient satisfaction survey about care delivery. There were included articles that took into consideration some of the aspects that affect the patient's perceived quality of the service provided (Tangibility, efficiency, professionalism, technical quality and communication), the Patient Satisfaction (Waiting Time, Perceived Value, Emotions, Fairness and Satisfaction Expectations) and the Patient Loyalty;

- ED crowding and hospital performance: there were included articles that analyzed the impact of ED crowding on ED performance using KPIs, such as: LWBS, waiting times in comparison with recommended time in accordance to the triage attributed priority level, time-averaged and total LOS, DTDT, Boarding Time, unplanned readmission within 14/30 days of discharge, unplanned transfer to any critical unit, decision-making time, perceived patient and health professionals quality of care or ED performance, patient satisfaction and use of equipment e.g. laboratory examinations and computed tomography (CT). KPIs were chosen based on broad acceptance as relevant measures of ED performance.

Literature Reviews, Systematic Literature Reviews, opinion articles, analysis from other studies and articles that focused on the causes of ED crowding were excluded.

Articles focused on the impact of ED crowding on clinical patient outcomes exclusively, were also excluded (measures of care quality – complications and comorbidities e.g. "the impact of ED crowding on early mortality"). Although they have clinically relevant endpoints that fit within the IOM quality domains (e.g. "mortality" – Safety and Effectiveness or "time to antibiotic" - Timeliness), they are considered clinical outcomes, instead KPIs – performance and quality outcomes. They are more clinical and less managerial oriented.

3.4. Data Analysis

Study selection and search results

The database research returned 451 articles, leaving a total of 407 articles after duplicates were removed.

After the initial review of titles and abstracts, 105 full text articles retrieved for full review with 18 of these satisfying all of inclusion criteria, 7 of these 18 articles were excluded, 4 were about ED crowding causes and 3 were about patient clinical outcomes (exclusion criteria), and therefore 11 articles were included in the final review.

Reporting items for systematic literature review and criteria

The search identified 451 articles: 111 from Scopus, 303 from Science Direct and 37 from PubMed. 11 out of 105 studies were eligible for the review. The entire search and selection process for articles is illustrated in Figure 3.4.1.

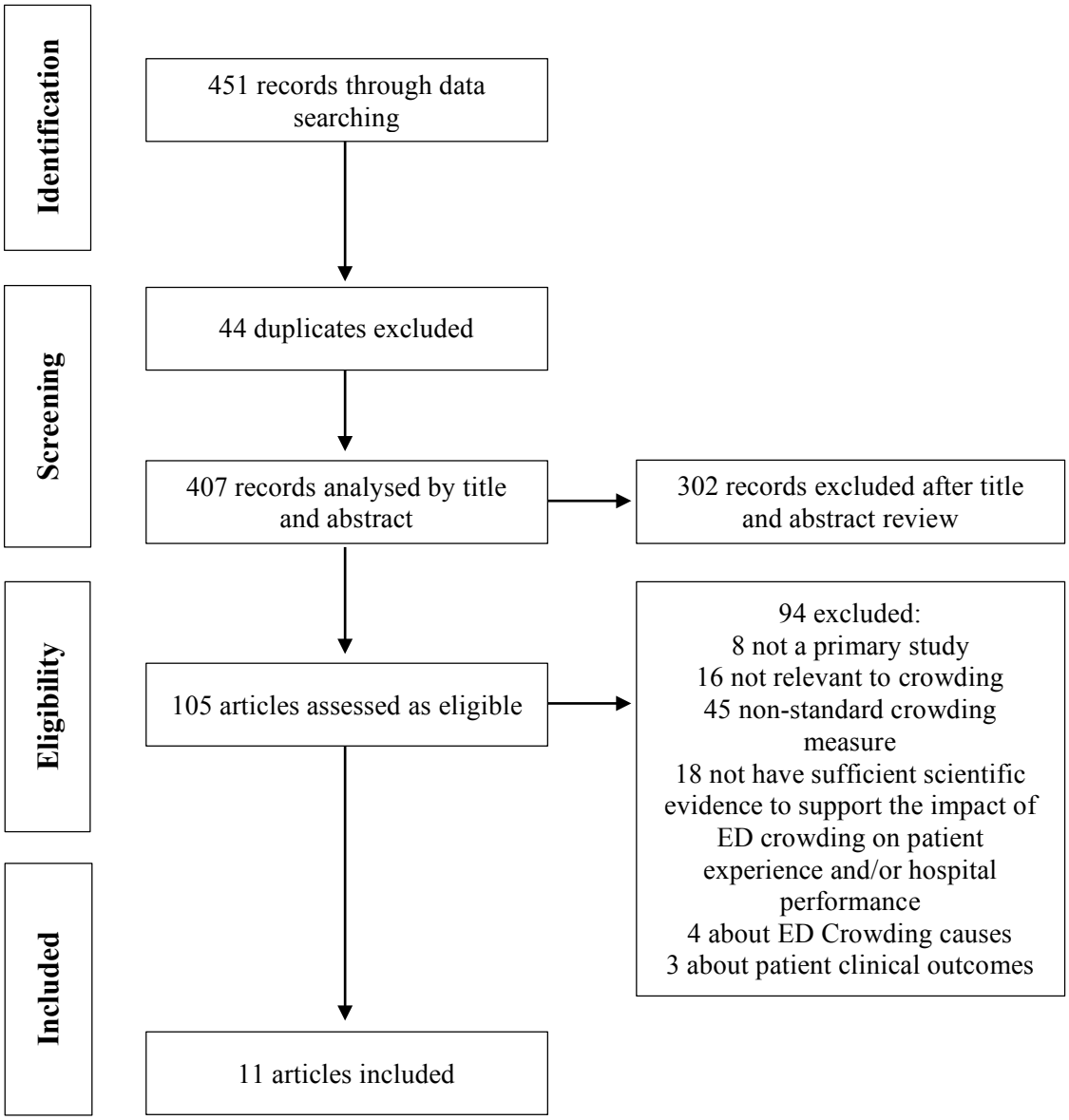

Figure 3.4.1. Study flow diagram. (Adapted from PRISMA 2009).

Study Quality Appraisal

Joanna Briggs Institute (JBI) levels of Evidence were used to determine the level of evidence of each selected article. To these authors, levels of evidence are scored from 1 to 5 according to the methodology of the study (Appendix C).

All 11 studies included were rated as Evidence level of three, classified as Observational - Analytic Designs in the 3.e. category of the Evidence Level: Observational studies without a control group, which correspond to eight articles (73%) or as Evidence Level of four, classified as Observational – Descriptive Studies in the 4.b.

category of the Evidence Level: Cross-seccional studies, which correspond to three articles (27%)[12].

All included articles were divided into three broad categories: the impact of ED crowding on patient experience, the impact of ED crowding on hospital performance and the impact of ED crowding on both. Articles about patient experience may fit under both strands: patient experience or hospital performance, since it is also considered to be a KPI, however only the articles that tested it using a survey were included in the category of the impact of ED Crowding on patient experience and hospital performance.

Accordingly, the findings have been summarized under the categories of ED crowding measure/scale, KPIs, impact of ED crowding on hospital performance, impact of ED crowding on patient experience and impact of ED crowding on patient experience and hospital performance.

12 Joanna Briggs Institute 2013. Level of Evidence. Available at: https://joannabriggs.org/sites/default/files/2019-05/JBI-Levels-of-evidence_2014_0.pdf . [accessed 9 Set, 2020].

4. Findings Presentation

Study Characteristics

The articles considered were six from United States of America (55%), one from Australia, one from Sweden, one from Belgium, one from Canada and one from Taiwan. These studies were all conducted between 2006 and 2020. All 11 studies included were rated as Evidence level of three or four.

Most of the articles were quantitative and retrospective (nine – 82%). Only one of the included studies was a multimethod and retrospective study and other was a quantitative and prospective study. There were four (36%) studies investigating the impact of ED crowding on the patient Experience (Table 4.1., more detailed in Appendix D), five (46%) investigating its impact on the performance of the hospital (Table 4.2., more detailed in Appendix E) and two (18%) studies investigating it on both (Table 4.3., more detailed in Appendix F).

Most of the studies (eight) were from 2013-2020 and only one of these studies is categorized on ED crowding and patient experience. There are three studies published over 10 years ago (2006-2008) and all studied the impact of ED crowding on patient experience. The largest proportion of studies addressed the impact of ED crowding on either patient experience or hospital performance (82%), represented on Tables 4.1. and 4.2..

ED crowding measure/scale

Eight of the included studies used as ED crowding scale ED Occupancy Rate, where one of the studies other than EDOR used EDWIN, (Tekwani et al., 2012).

Two of the included studies associated some ED crowding measures with EDOR:

- Pines et al. (2008) pointed out as ED crowding factors:
- hallways placement;
- patient-level crowding exposures:
    - boarding time;
    - waiting time - the time from ED triage to room placement;
    - ED treatment time - the time from triage to ED departure.
- ED crowding exposures:
    - EDOR;
    - number of admitted patients;

    - patient-hours (the sum of the total hours all patients including waiting room patients and admitted patients have spent in the ED);
    - recent LOS for admitted patients (average LOS for admitted patients who were transferred to inpatient beds in the 6 hours prior to triage time);
    - number of patients in the waiting room.
- Pines et al. (2007) associated EDOR with total LOS, number of admitted patients, number of ED patients and number of nurses in ED.

There was one study that used NEDOCS and SONET in association with patient perception of ED Crowding. It was observed a considerable agreement between the NEDOCS and SONET assessment of ED crowding (bias = 0.22; 95% limits of agreement (LOAs): −1.67, 2.12), (Wang et al., 2017).

The authors of the remain studies instead of using EDOR as the main ED crowding measure only used indicators such as: median LOS, median IPLOS, DTDT, Boarding time (Mullins and Pines, 2014), health professionals' rates of crowding to measure of ED crowding (Vieth and Rhodes, 2006) and LWBS (Mullins and Pines, 2014 and Vieth and Rhodes, 2006).

KPIs

Four of the included articles used Patient Satisfaction as the only KPIs. Those that have been categorized as ED crowding and Patient experience (Wang et al., 2017, Tekwani et al., 2013, Pines et al. 2008 and Pines et al. 2007). The remain articles studied ED crowding and hospital performance which means other KPIs were used to measure the hospital performance.

All studies used a different combination of KPIs, even so some were present in more than one study such as: LOS (Stephens, A. and Broome, R., 2019, Ugglas et al., 2020 and Chiu et al., 2018); Unplanned readmission within 7, 14 or 28 days of discharge (Stephens, A. and Broome, R., 2019, Ugglas et al., 2020 and O'Connor et al., 2014); DTDT in comparison with recommended time according to the triage attributed priority (Stephens, A. and Broome, R., 2019 and Bergs et al., 2014); Mortality within 30-days (Ugglas et al., 2019 and Mullins and Pines, 2014) and Patient satisfaction (Mullins and Pines, 2014 and Vieth and Rhodes, 2006);

The remain KPIs included in only one study were:

- DTDT (O'Connor et al., 2014);
- Decision-making time (Chiu et al., 2018);

  - LWBS (Vieth and Rhodes, 2006);
  - Inhospital mortality (Ugglas et al., 2020);
  - ED mortality (Chiu et al., 2018);
- Number of patients discharged (Chiu et al., 2018);
- Number of patients admitted in Intensive Care Unit (ICU) or other department (Chiu et al., 2017);
- Outpatient perception of efficiency (Mullins and Pines 2014);
- Clinical complications: HAC and healthcare associated infections (Mullins and Pines, 2014);
- Readmission rates (Mullins and Pines, 2014);
- Health professionals' perception of quality of care (Vieth and Rhodes, 2006);
- Utilization and productivity KPIs: use of equipment (Chiu et al., 2018).

ED Crowding and Patient Experience

Patient experience was tested through several patient satisfaction surveys, where some indicators were included: timeliness and efficiency (waiting times and LWBS), communication with health professionals (participation in the healthcare process), technical quality (e.g. managing patients' pain), environment conditions (e.g. hallway placement), professionalism (e.g. confidentiality), accessibility (access to ED) and overall satisfaction and recommendation of the ED.

It was recorded all mean satisfaction scores and obtained mean ED occupancy rate (Tekwani et al., 2013), it was attributed an ED crowding score to each patient upon registration at ED (Wang et al., 2017) or it was analyzed the association between ED crowding validated indicators and patient satisfaction, using a survey (Pines et al., 2008 and Pines et al. 2007).

This systematic literature review revealed that the ED crowding is associated with reduced patient satisfaction (Wang et al., 2017 and Tekwani et al. 2013), once the likelihood of failure to meet patient satisfaction goals was associated with an increase in average EDOR (odds ratio [OR] 0.32, 95% confidence interval [CI] 0.17 to 0.59, $P < 0.001$, Tekwani et al. 2013).

Besides, it has a significant impact on the patient perceptions of compromised emergency care, that are strongly associated with environment conditions - hallways placement (OR, 2.02 [95% CI = 1.12 to 3.68]) and efficiency and timeliness - increased

waiting times (odds ratio [OR], 1.05 for each additional 10-minute wait [95% confidence interval {CI} = 1.02 to 1.09]; Pines et al., 2008).

Likewise, ED crowding has a strong impact on Healthcare professionals' perceptions of compromised emergency care. Nurses and Doctors argue ED crowding impacts negatively technical quality (management of pain is perceived to be poorly controlled), patient safety, patient-centred care delivery (it is associated with higher number of patients present at the same time in ED (OR, 1.05 for each additional patient waiting [95% CI = 1.02 to 1.07]), health professionals are overloaded), efficiency and timeliness (it is associated with the perception that exams and administration of medication take longer and prolonged waiting times (OR, 1.05 for each additional 10-minute wait [95% CI = 1.01 to 1.08]), prolonged boarding time after admission - AB (OR, 1.08 for each additional patient [95% CI = 1.03 to 1.12], Pines et al. 2007).

For patients, the indicators that have the strongest impact on their perception of the quality of care, satisfaction and posterior recommendation of the service are the waiting times and LWBS.

All identified studies revealed an association between ED crowding and patient satisfaction.

ED Crowding and Hospital Performance

Report impacts of ED crowding on hospital performance showed an association between ED Crowding and:

- an increased DTDT for non-urgent triaged patients (e.g. rate ratio = 2.22, 95% confidence interval [CI] [2.10–2.35], Stephens, A. and Broome, R., 2019);
- a longer DTDT (107.3 – 76.0 minutes, O'Connor et al., 2014);
- a longer LOS (increased 16-minute - Ugglas et al., 2020 and by 1.1 h - Chiu et al., 2018);
- a higher risk of readmission to the ED within 7 days (EDOR levels greater than 89% had 2 % to 4% higher risk of readmission to the ED within 7 days, Ugglas et al., 2020);
- an increased physicians' decision-making time (LOS increased by 0.3 h, Chiu et al., 2018);
- a lower percentage of patients discharged (by 15.5%, Chiu et al., 2018);

- a higher admission rate to observation units, general and ICUs (by 10.9%, 4%, and 0.7%, respectively, Chiu et al, 2017);
- a higher rate of triage (CTAS score of 2 were triaged more often, O'Connor et al., 2014);
- a higher rate of triage to the non-monitored area of the ED, for high acuity patients presenting with chest pain or shortness of breath (25.5% - 16.3%, O'Connor et al., 2014);
- a declined in admission rate to inpatient care, which indicates that in crowded conditions a medical prioritization is taking place: older or sicker patients are admitted (1.9% decrease in admission rate, Ugglas et al., 2019), which both increase the workload in ED;
- an increased use of equipment and number of examinations;
- unsafe waiting times (patient waiting time in ED is higher than what is recommended according to its triage attributed priority) it occurred 16.0% of ESI-1 patients and 18.9% of ESI-2 patients (Bergs et al., 2014).

It was identified on literature an association between ED crowding and several KPIs, demonstrating that it has a negative impact on hospital productivity, quality and operational, logistic and financial performance.

ED Crowding and Patient Satisfaction and Hospital Performance

Report impacts of ED crowding on both affected strands. It was found that ED crowding was related with several measures of ED performance such as: patient satisfaction, unplanned readmission rates, HAC, LOS and LWBS.

ED crowding was associated with prolonged LOS that decreased patient satisfaction (patient reported hospital as 9 or 10 r= - 0.23, p< .001), increased LWBS (r= -0.14, P < .001, Mullins et al., 2014) and increased boarding times, which also increased healthcare-associated infections (r = 0.37, P < .001) and unplanned readmission rates for AMI and pneumonia (r = 0.14, P b .001 and r = 0.17, P b .001, respectively, Mullins and Pines, 2014).

Vieth and Rhodes (2006) studied an academic ED in USA, the rate of LWBS during the time of the study the rate of LWBS was 9% and most of the patients who LWBS were of non-urgent/stable triage acuity (RR = 3.1; 95% CI, 2.5-3.8). This outcome measure is consistent with existing literature (>5%, which means ED is crowded and is inefficient).

In 47% of 57 shifts, at least one healthcare professional felt that crowding was compromising quality of care. On average, patients felt that they should be seen within 1 hour but expected to wait for 2.1 hours. Patient's perceived that waiting times on follow-up averaged 3.5 hours, 5+ hours for LWBS patients. ED satisfaction was inversely related to patient's perceived waiting times. ED crowding restricts access to ED (decreased accessibility) and compromises the quality of care as perceived by patients and health professionals (Vieth and Rhodes, 2006).

Table 4.1. Characteristics of included studies investigating the impact of ED crowding on Patient Experience. (Self-elaboration based in the systematic literature review).

Ref.	Measures	Objectives	Methodology	Findings
Wang et al. 2017 USA.	ED crowding scale: NEDOCS, SONET and Patient perception. Triage scale: ESI. Outcome measures: Patient real-time satisfaction.	To evaluate the associations between real-time overall patient satisfaction and ED crowding as determined by patient perception and crowding estimation tool.	A prospective observational study. First: attribute ED crowding score to each patient; Second step: collect patient satisfaction from real-time patient surveys.	1345 participants: Higher degrees of ED crowding at admission might be associated with lower real-time patient satisfaction.
Tekwani et al. 2013 USA.	ED crowding scale: EDOR, EDWIN and Hospital diversion status. Triage Scale: ESI. Outcome measures: Patient satisfaction.	To evaluate the impact of ED crowding on patient satisfaction in patients discharged from the ED.	A Retrospective, cohort study of all patients discharge from ED in a teaching hospital and completed Press-Ganey patient satisfaction surveys. Recorded mean satisfaction scores and obtained mean EDOR, mean EDWIN score and hospital diversion status.	1591 surveys: crowding, as measured by EDOR and EDWIN score, was significantly associated with reduced patient satisfaction.
Pines et al. 2008 USA.	ED crowding measures: hallways placement, waiting times and ED crowding exposures. Outcome measures: Patient ED satisfaction and Inpatient satisfaction.	To study the association between factors related to ED crowding and patient satisfaction.	A retrospective cohort study. Patient satisfaction surveys. It was study the association between validated ED crowding factors and patient satisfaction with ED care and with the overall hospitalization.	1,469 patients: a poor ED experience is adversely associated with ED crowding, satisfaction and a lower likelihood of recommending the ED to others.
Pines et al. 2007 USA.	ED crowding measures: total LOS, EDOR, number of admitted patients, number of ED patients and number of nurses in ED. Outcome measures: Patient, nurses and physicians' perceptions.	To measure the association between ED crowding and patient and provider perceptions about whether patient care was compromised.	A cross-sectional study. Linked patients, nurses and physicians' surveys. Primary outcome: agreement on a five-item scale assessing ED crowding compromised care and determine its association with ED crowding measures. Second outcome: survey about perception of ED crowding compromise care.	644 patients 703 physicians and 716 nursing surveys:16% of patients, 12% of doctors, and 24% of nurses reported that care was compromised by ED crowding. Predictors of compromised care: waiting time (patients and nurses); hallway placement (patients); number of patients in ED and number of admitted patients waiting for an inpatient bed (nurses and doctors).

Table 4.2. Characteristics of included studies investigating the impact of ED crowding on Hospital Performance. (Self-elaboration based in the systematic literature review).

Ref.	Measures	Objectives	Methodology	Findings
Stephens, A. and Broome, R. 2019 Australia.	ED crowding scale: EDOR. Outcome measures: ED waiting time in comparison with recommended time; unplanned readmissions within 28 days and LOS when admitted.	To assess the association between ED crowding and relevant outcomes including: ED waiting times, rates of admission and representation and LOS when hospitalized.	Retrospective study of all ED presentations. An ED-system measure of occupancy was assigned to each ED record.	N = 935 282: Higher ED occupancy was associated with increased waiting times conditional on triage category, such that waiting times were increased for less urgent patients but less so for emergency or resuscitation patients.
Ugglas et al. 2020 Sweden.	Crowding scale: Bed Occupancy. Outcome measure: Mortality within 30 days; Inhospital mortality; Unplanned readmission within 30 days of hospital discharge; Unplanned readmission within 7 days of being discharge and LOS.	To evaluate the importance of hospital bed occupancy for 30-day mortality, inhospital mortality, readmission for inpatient care within 30 days and revisits to the ED within 7 days among patients visiting the ED.	An observational cohort study. Information was extracted from the electronic health care records system. Included: patients aged 18 years old with a personal Swedish personal identity.	A total of 816,832 patients with 2, 084,554 visits: mean hospital Bed Occupancy was 93.3%. There is an association between increasing bed occupancy and a longer LOS (10 % increase in hospital bed occupancy was associated with 16-minute increase in ED LOS), a higher risk of readmission to the ED within 7 days (patients discharged from the EDOR levels greater than 89% had 2 % to 4% higher risk of readmission to the ED within 7 days) and a declined in admission rate to inpatient care (1.9%).
Chiu et al. 2018 Taiwan.	ED crowding scale: EDOR. Triage Scale: TTAS. Quality/performance measures: Efficiency: Decision-making time and LOS; Patient disposition: ED discharge, ED observation, general and ICU admission and ED mortality; ED diagnostic tool use: use of laboratory examinations and computed tomography (CT).	To clarify the association between the crowding and clinical practice in the ED.	A retrospective 1-year cohort study conducted in two EDs.	70,222 adult non-trauma visits during the day shift: ED Crowding might increase physicians' decision-making time and patients' LOS, (by 0.3 h and 1.1 h, respectively) and more patients could be admitted to observation units or an inpatient department (percentage of patients discharged decreased by 15.5% as the ED observation, general and intensive care unit admissions increased by 10.9%, 4%, and 0.7%, respectively. The use of CT and laboratory examinations would also increase.

Bergs et al. 2014 Belgium.	ED crowding scale: EDOR. Triage Scale: ESI. Outcome measures: waiting times in comparison with recommended time.	To investigate whether the number of patients simultaneously present at the ED might be an indicator of unsafe waiting.	A retrospective observational study. Data was collected from the hospital information system. Variables regarding triage, waiting time and time of registration were obtained. A second dataset, containing the number of patients simultaneously present, was used to calculate the occupancy rate at each patient's registration time. ED patients aged >16 years and triaged as ESI-1 or ESI-2.	ED Crowding affects waiting times and it is a moderate indicator of unsafe waiting time. The overall median waiting time was 5 min for ESI-1, and 12 min for ESI-2 patients. Unsafe waiting times occurred in 16.0% of ESI-1 patients and in 18.9% of ESI-2 patients. The ODOR was a fair indicator for unsafe waiting times in ESI-2 patients.
O'Connor et al. 2014 Canada.	Crowding measure: EDOR Triage scale: CTAS. Outcome measure: DTDT, Unplanned readmission and within 14 days.	To determine if ED crowding influenced patient triage destination and intensity of investigation, as well as rates of unscheduled returns to the ED. Authors focused on patients, triaged as high acuity (presenting with chest pain or shortness of breath), and who were subsequently discharged home.	A Retrospective cohort study was developed in two ED campuses of large urban tertiary care academic teaching hospital. A health records review of patients presenting was developed. Included: patients older than 18 with either chest pain or shortness of breath assign with a triage score 2.	500 health records and 4,234 patients' visits were studied: when ED was crowded - CTAS score of 2 were triaged more often, DTDT was longer (107.3 – 76.0 minutes) and high acuity patients presenting with chest pain or shortness of breath had a higher rate of triage to the non-monitored area of the ED (25.5% - 16.3%). ED crowding conditions influence triage destination in this ED leading to longer waiting times for high acuity patients.

Table 4.3. Characteristics of included studies investigating the impact of ED crowding on Patient Experience and Hospital Performance. (Self-elaboration based in the systematic literature review).

Ref.	Measures	Objectives	Methodology	Findings
Mullins and Pines 2014 USA.	ED crowding measures: median IPLOS, median LOS, Boarding time, DTDT and LWBS. Outcome measures: readmission rates; complications: AMI, healthcare-associated infections, HAC and pneumonia; Outpatient imaging efficiency; 30-day mortality and Patient Experience.	To assess characteristics of reporting vs non-reporting hospitals. To compare ED performance in ranked and unranked hospitals and assess relationships between ED crowding and reported hospital quality measures. To assess possible effects of educating medical students and residents on ED crowding.	An exploratory investigation of Hospital Compare's ED crowding measures, using data from downloadable Hospital Compare data files about KPIs and "top-ranked hospitals" and data from HCAHPS patient surveys.	4810 hospitals included: ED crowding was related to: LOS, LWBS, unplanned readmission rates and HAC. 62.2% reported all ED 5 crowding measures. Median IPLOS was 262 minutes, median boarding time was 88 minutes, median LOS for discharged patients was 139 minutes and median DTDT was 30 minutes. ED crowding was associated with lower patient satisfaction, with higher rates of HAC, and higher unplanned readmission rates. Higher LOS was associated with lower patient satisfaction. LWBS is adversely associated with the percentage of patients that would recommended the ED. Emergency department boarding times were associated with unplanned readmission rates for AMI, pneumonia and healthcare-associated infections.
Vieth and Rhodes 2006 USA.	ED crowding scale: LWBS and Providers rates of crowding. Triage system: 1-5 scale. Outcome measures: LWBS rate, provider perceived quality of care and Patient satisfaction.	To evaluated ED access and provider and patient assessments of quality.	Multimethod study developed in an academic ED. Descriptive analysis of administrative records, health professionals and patient surveys. Health professionals rated the level of ED crowding and perceived effect on patient care. The average ED crowding rating of the 2 health professionals was correlated with LWBS rate during the subsequent 6 hours.	11 743 patients registered, and 9% LWBS. ED crowding increased LWBS and decreased patient satisfaction. ED crowding restricts access to ED and compromises the quality of care as perceived by patients and providers. Doctors and nurses had 81% agreement in their assessment of crowded conditions, which were temporally associated with LWBS rates. In 47% of 57 shifts, at least 1 health professional felt that crowding was compromising quality of care. On average, patients felt they should be seen within 1 hour but expected to wait for 2.1 hours. Patient's perceived that wait times on follow-up averaged 3.5 hours, 5+ hours for LWBS patients. ED satisfaction was inversely related to patient's perceived wait times.

Limitations

A systematic literature review was applied, because this study took place during a pandemic crisis of COVID-19 and it was not possible to develop a primary study in one hospital in Portugal.

These results have several limitations. Most of the articles cited represent single-institution observational cohorts, and no randomized controlled trials were identified. Hence, the strength of the evidence is modest at best (Level of Evidence: 3-4). Also, Quality assessment methods were non-standardized and operational definitions for individual quality items were not always explicitly provided.

There is a lack of criterion standards methods of measuring ED Crowding and of articles that use a scale or measures validated in literature in their studies. Few articles were included in the final review, therefore, the ability to effectively answer to the research questions is limited to only 11 studies (it was not included any article that emphasized or quantified the impact of ED crowding on the financial performance of the hospital, measured by budget-related KPIs). Also, included articles used different scales, which validity had been inconsistent in studies published.

There are many factors that can be potential issues, which can generate biased conclusions, such as: attributed priority to patients in triage, meaning that patients with an emergent priority (e.g. Red Priority in MST) were excluded from most of the studies.

5. Discussion and conclusions

The literature on ED crowding was critically analyzed, specifically on its impact on patient experience and hospital performance in attempt to answer four questions: 1) What are the indicators of Emergency Department crowding? 2) What are the Key Performance Indicators (KPIs) used in hospital to measure their performance in EDs? 3) How does Crowding have impact on the acutely ill patient experience in ED? 4) How does the ED Crowding have impact on the ED performance?

ED crowding measure/scale

A review of multivariate literature confirmed there is a lack of consensus on the terminology used to refer to ED Crowding, on an operational definition to identify it, since there were some articles using the terms "ED overcrowding", "crowding" or "overcapacity".

Also, as there were excluded 45 articles, that analyzed the impact of ED crowding on patient experience and/or hospital performance but did not used a standard crowding measure or scale, it confirmed the absence of agreement on a system or scale to measure it. Only by using a standard, uniformed and international scale or measure it is possible to study ED crowding's impact as scales and measures can be used in real-time and integrated with clinical information systems.

Most of the included articles revealed that the strongest predictor and overall best indicator of ED crowding is EDOR, once it is easy to calculate, can be used in real-time situations and different contexts and is significantly associated with the healthcare professionals' perception of crowding and quality of care. Moreover, there are some studies in literature that define a crowded ED as an ED where the number of patients is higher than the number of treatment spaces in it, which is the definition of EDOR.

It seems to exist a considerable agreement between the NEDOCS and SONET assessment of ED crowding and the patient perception of it, though not considered as accurate and simple as EDOR.

There were some studies in literature measuring ED crowding throughout key performance indicators instead of using an ED crowding scale. The most common used measures are the ones proved to be more associated with ED crowding, which are:

- ED utilization indicators or time-related KPIs (key time sensitive service delivery measures to evaluate the ED performance) - time until triage/time to initial assessment, total LOS, DTDT and ED boarding time;
- Patient safety and satisfaction KPIs - LWBS;
- ED crowding exposures: the number of admitted patients and patient-hours.

KPIs

To analyze the impact of ED crowding on hospital performance, investigators identified first KPIs and then analyzed the association of ED Crowding with each one of them.

The review revealed that the most used KPIs that measure the ED performance and quality of care were: LOS (measuring Safety as it influences treatment adherence and Timeliness), unplanned readmission rates, mortality within 30-days, DTDT in comparison with recommended time according to the triage attributed priority (measuring Safety), DTDT (measure of timeliness) and Patient satisfaction or perception of quality care and performance (measuring patient-centred care delivery, if care responds to individual preferences and values, measuring timeliness, efficiency, equity and safety).

Other indicators found in literature were: LWBS, number of patients admitted in ICU or other department, clinical complications and ED mortality, that measure patient safety. The number of admitted patients, nurses/patients' ratio and patient-hours, measuring patient-centred care delivery. Costs and the use of equipment, measuring efficiency.

Some authors referred that patient and healthcare professionals' perceptions of quality care and performance are the most important performance indicators.

Productivity and Utilization KPIs were considered the least important group to measure ED performance.

ED Crowding and Patient Experience

Literature review revealed that patient experience in the ED encompasses a range of interactions between patients and the healthcare system, including their care from health plans and health professionals, that influence patient perception across the delivery of care. Patient experience is a component of healthcare quality and a KPI, alongside providing clinical excellence and safer care.

Patient experience was analyzed using surveys (e.g. Patients who LWBS were asked if their problem had been resolved without treatment and how long they waited before

LWBS, reasons for leaving, and what might have prevented their leaving and patients who remained for treatment are asked what their waiting times have been, along with an assessment of quality, satisfaction, problem resolution, and adherence to recommended follow-up). All articles revealed that there is a strong association between ED crowding and patient experience (rate of LWBS, satisfaction, amongst others).

Literature review revealed that ED crowding is associated with patients and health professionals' perceptions of compromised emergency care, once it impacts negatively the perception patients have about: the management of pain, which is perceived to be poorly controlled (technical quality), confidentiality (professionalism), participation in the healthcare process (communication), waiting times, exams and administration of medication are perceived to take longer and LWBS (timeliness), environment conditions and privacy and dignity (hallways placement) and access to ED (accessibility).

Therefore, it is possible to conclude that ED crowding causes a reduction in patient's safety, privacy, confidentiality, dignity and completeness of care, it creates delays and more barriers in the participation in the decision-making process for treatment, it increases costs for patients and decreased quality in healthcare delivery, all these factors compromise the patient's overall satisfaction and trust in the ED and contribute to a poor patient experience, which will decreased patient loyalty and future recommendation of the service, decreasing the hospital profit.

Literature revealed that ED crowding contributes to a poor patient experience, once it has impact on several domains of healthcare system that are used to assess hospital performance and quality of care, such as: safety, efficiency, timeliness, patient-centred care delivery and patient's perceived quality of care and overall satisfaction.

ED Crowding and Hospital Performance

Emergency department crowding was related to several measures of operational, logistics and financial performance.

Research showed that ED crowding was associated with timeliness as it increased LOS, DTDT, decision-making times and boarding times.

Also, its negative impact on the LOS, might delay patient treatment and resuscitation effort, affecting patient prognosis and contributing to a higher rate of inpatient mortality.

This systematic literature review showed an association between ED crowding and safety, as it increased unsafe waiting times for non-urgent triaged patients, since it leads to increased waiting times for less urgent patients but less so for emergency or

resuscitation patients. It also, increased healthcare associated infections, pneumonia, AMI and admission to other departments (as ICU, observation and general units), because there is less time to evaluate, manage, and instruct patients in a crowded ED and physicians tend to keep patients in the ED longer or just admit them to make sure that adverse outcomes do not occur. It increased medical errors, unplanned readmission rates and ED mortality. Plus, it decreased admission rate to inpatient care, indicating that in crowded conditions a medical prioritization is taking place: older or sicker patients are admitted and decreased the percentage of patients discharged.

Besides, it revealed that ED crowding was associated with efficiency, once it increased healthcare costs and inpatient admissions contributed to cost and use of laboratory examinations and CT and decreased productivity and communication between medical staff.

Also, it exposed an association between ED crowding and patient-centred care delivery, as it increased the number of patients in the waiting room, patient-hours and nurses/patients' ratio.

Finally, it was not reported an association between ED crowding and equity and effectiveness in any of the included articles.

ED Crowding and Patient Experience and Hospital Performance

Regarding the impact of ED crowding on patient and hospital, it was possible to report its negative effect on each one of the KPIs that were assessing hospital performance and then analyzed its impact on the patient's perception of ED quality, which contributed negatively to the overall patient satisfaction, in a more detailed approach, once, it was taken into consideration the two affected strands.

Not only patient's satisfaction was tested using a survey but, also indicators (KPIs and quality measures) were identified that when affected by ED crowding had a negative influence on patient experience. The patient experience could be used as a qualitative indicator to measure the hospital performance and therefore to improve the ED healthcare services quality and operational, logistics and financial performance.

All these evidences prove that the ED performance and patient experience influence each other mutually.

The impact of ED crowding on hospital performance was measured by KPIs and its impact on patient experience was measured by patient satisfaction.

ED crowding was negatively related to several measures of quality and hospital performance and that it had a negative impact on patient's outcomes and perceived quality of care, which were adversely associated with ED satisfaction.

Although numerous studies suggested that patient satisfaction was widely discussed in the healthcare industry and was influenced by patient's expectations to the service. It had an influence in the future behavioural intensions of each patient namely its loyalty to the service or to health professionals, deciding whether to recommend the service, that influence the hospital's management and profit. Therefore, it was considered a great performance indicator for hospitals.

All these findings are summarized in Figure 5.1.

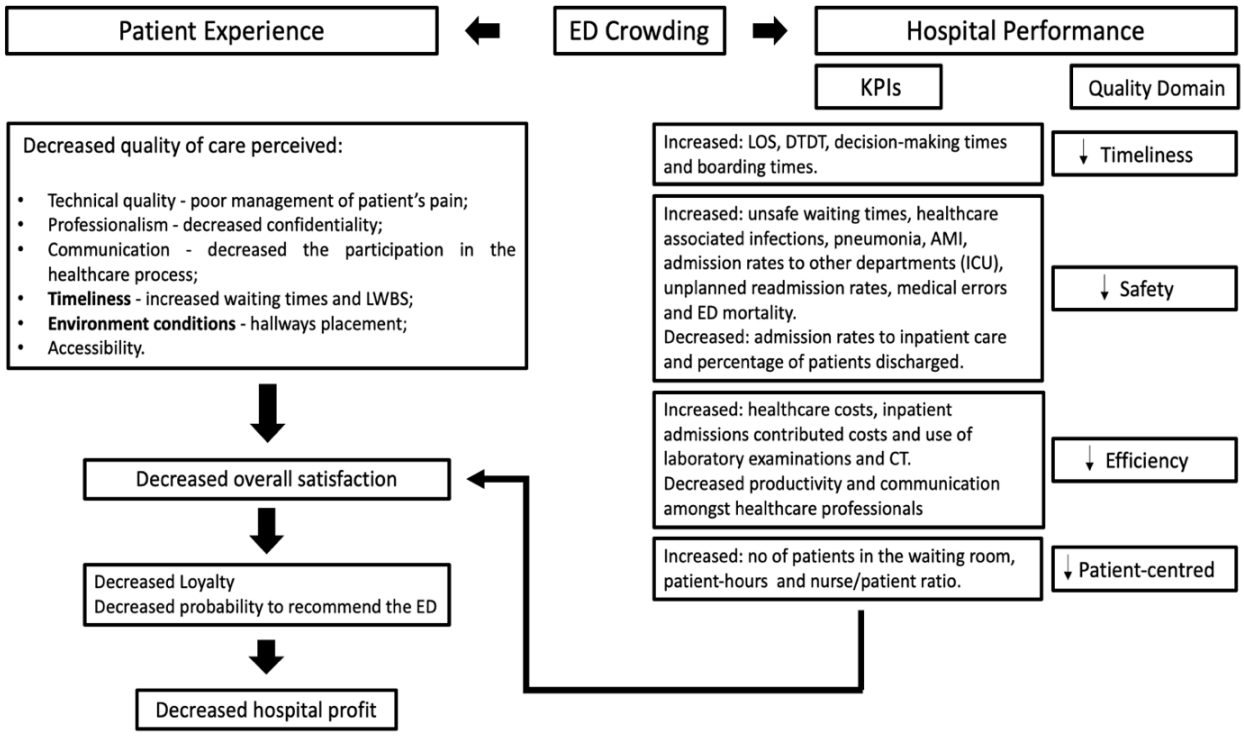

Figure 5.1. The impact of ED crowding on Patient experience and hospital performance. (Self-elaboration based in the systematic literature review).

All these results suggest ED crowding should be a hospital-wide priority for quality and performance improvement efforts.

Future Research

Multiple studies have reported crowding as a growing problem in recent years. Most studies were developed in the United States, Australia, and Canada; however, this problem is occurring in many developed countries as Portugal. In the future, it would be

interesting to develop a primary study about this subject in Portugal, once ED crowding is point out as one of the biggest problems in the Portuguese healthcare sector and there is a lack of studies investigating the Portuguese reality on this matter.

National statistics about the EDs of the two hospitals with more visits in Portugal in 2019[13] revealed that: in Hospital de Santa Maria, the LWBS rate was 6,4% (>5%) and the time-averaged DTDT in minutes attributed by priority was superior than the maximum time recommended in yellow (was 77 minutes instead of 60 minutes); orange (was 21 minutes instead of 10 minutes) and red (was 10 minutes instead of 0 minutes) priorities and in Hospital de São João, the LWBS rate was 6% and the time-averaged DTDT in minutes attributed by priority was superior than the maximum time recommended in yellow (was 98 minutes instead of 60 minutes) and orange (was 13 minutes instead of 10 minutes) priorities (ACSS, 2016).

It is possible to conclude that these EDs are constantly crowded and are performing inefficiently, according to literature. With the fast-changing pace of research, the complex and unpredictable environment in the emergency healthcare sector and the existing differences amongst public health systems across the world, it was anticipated that in a different context (Portugal), there could be different results. All this stress the importance of such study in Portugal.

In the future, it would be interesting to implement EDOR or to validate a scale of ED crowding in Portuguese EDs and start adapting processes and operations according to its score. Once, only by using a standard, uniformed and international scale or measure it is possible to study ED crowding's impact, as scales and measures can be used in real-time and integrated with clinical information systems. That way it would be possible to anticipate the demand in EDs and to adapt the management of material, physical and human resources in a more accurate and customized way, minimizing the consequences of this phenomenon on hospital and on patients.

For future research, it would be important to test the patient satisfaction and to analyze the ED performance in real time and in a specific context to better forecast the occupancy rate. It is possible to use data reported hourly on an ED electronic system on the number of patients under evaluation and the licensed treatment spaces (EDOR) to have a crowding score, while applying the survey developed by Polónia (2020) to test patient satisfaction. First, an objective ED crowding score using EDOR, measured hourly, would

13 Portuguese National Health Service (NHS). 2020. *Serviços de Urgência*, available from: https://www.sns.gov.pt/monitorizacao-do-sns/servicos-de-urgencia/ [accessed 10 Jan, 2020].

be assigned to each patient at its registration time and simultaneously test the patient satisfaction using a survey upon their individual dispositions, handed at discharge.

Then, it would be tested the correlation between the ED crowding variable and the patient satisfaction variable. Finally, it would be analyzed the patient satisfaction survey outcomes, highlighting each dimension of the survey that is also a KPI, to identify the KPIs that were affected by crowding and those who are not - to test the correlation between the ED crowding variable and the hospital performance variable. That way it would be possible to analyze the impact of ED crowding on patient experience and on hospital performance, perceived by patients.

This study could be developed in the two more visited EDs in Portugal (as mentioned above) to achieve new findings about the real impact of ED crowding, assessing KPIs adapted to Portuguese hospitals, to develop future strategies based on real-time situations and interventions that are adapted to the degree of ED crowding and its influence on patient satisfaction and hospital performance.

At last, future studies would benefit by focusing its investigation on strategies and interventions to minimize the damage caused by this problem, taking as a starting point previously developed studies on ED crowding cyclic changes and its causes. Plus, it would be useful to develop a new study that assessed in what way ED crowding impacts each specific factor that influences patient satisfaction, identified previously in this dissertation, and not just its effect on the overall satisfaction. Although numerous studies suggested that patient satisfaction was widely discussed in the healthcare industry, there were developed few articles about this matter in recent years.

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Appendix

Appendix A – Patient Satisfaction Survey

Appendix A – Patient Satisfaction Survey. (Addapted from Polónia, et al., 2015)

Questões Qualidade do Serviço Percebida	Hipóteses	Adaptação dos Autores
Tangibilidade (TA)	H1a	Qin & Prybutok, 2012; Chahal & Mehta, 2013; Sofaer & Firminger, 2005; Thompson, Yarnold, Williams, & Adams, 1996.
TA1- As instalações têm boa aparência, são amplas, iluminadas, limpas e bem decoradas, tendo o equipamento médico um aspecto moderno.		
TA2- As instalações proporcionam um conjunto de serviços complementares (eg: cafetaria) variados e de qualidade, servidos num ambiente tranquilo e agradável.		
TA3- As instalações aparentam ser seguras e proporcionam um acesso fácil e imediato aos visitantes.		
TA4- Os profissionais apresentam-se vestidos de forma adequada ao trabalho que desenvolvem.		
Eficiência (EF)	H1b	Sofaer & Firminger, 2005; Qin & Prybutok, 2012.
EF1- Os profissionais envolvidos na prestação dos cuidados revelaram capacidade de coordenação e de colaboração entre si.		
EF2- A assistência prestada foi continua, com encaminhamento atempado e exames e tratamentos sincronizados entre si.		
Profissionalismo (PR)	H1c	Qin & Prybutok, 2012; Chahal & Mehta, 2013.
PR1- O processo administrativo de admissão foi efetuado de forma correta, tendo sido recolhida toda a informação necessária.		
PR2- Os profissionais (médicos e enfermeiros) aparentaram ter conhecimentos e experiência no tratamento do meu caso.		
PR3- Os profissionais (médicos e enfermeiros) atuaram de forma rápida, oportuna e eficaz na assistência médica.		
PR4- Os profissionais (médicos e enfermeiros) comunicaram e comportaram-se de forma adequada à situação.		
Qualidade Técnica (QU)	H1d	Sofaer & Firminger, 2005; Qin & Prybutok, 2012.
QU1- Os profissionais recomendaram os exames e os tratamentos mais adequados à minha situação.		
QU2- Enquanto paciente fiquei impressionado com o atendimento.		
QU3- Enquanto paciente considero que os cuidados recebidos foram de excelente qualidade.		
Comunicação (CO)	H1e	Katz et al., 2013; Sofaer & Firminger, 2005.
CO1- Enquanto paciente, senti-me envolvido no processo de tratamento, sendo que senti que os profissionais de saúde me ouviram sem pressa.		
CO2- As explicações que me foram prestadas no atendimento e no tratamento foram as mais adequadas, tendo sido prestadas sem falhas nem lapsos e de forma clara e compreensível.		
CO3- As informações recebidas identificaram claramente as causas e os sintomas subjacentes ao meu problema.		
CO4- Fui informado do diagnóstico efetuado, do prognóstico clínico e da forma de como deverei retomar a minha vida normal.		
Tempo de Espera (TE)	H2	Thompson, Yarnold, Williams, & Adams, 1996.
TE1- O tempo que decorreu entre a triagem e a consulta foi o que previa e achava apropriado.		
TE2- O tempo entre a triagem e a alta foi o que previa e achava apropriado.		
Valor percebido (VA)	H3	Choi, cho, Lee, Lee, & Kim,2004.
VA1- Sinto que recebi um serviço de boa qualidade, numa instituição de prestígio.		
VA2- O preço que paguei pelo serviço foi o adequado (caso seja isento de taxa moderadora, coloque-se na posição dos não isentos).		
VA3- Durante o processo de atendimento e tratamento estive sob stress físico e mental.		
Equidade (EQ)	H6	Vinagre & Neves, 2010.
EQ1- Fui atendido e tratado de forma justa face à gravidade da minha situação.		
EQ2- Recebi a mesma atenção e atendimento que outros pacientes em situação similar.		
Expectativas de Satisfação (EX)	H7	Vinagre & Neves, 2008.
EX1- Face ao que esperava, estou satisfeito com o atendimento e tratamento recebido.		
Satisfação (SA)		Sun, Adams, & Burstin, 2001.
SA1- Estou satisfeito com o atendimento que recebi no Serviço de Urgências.		
Lealdade (LE)	H8	Chahal & Mehta, 2013
LE1- Recomendo este serviço a outras pessoas na mesma situação.		
LE2- Caso necessite de cuidados de urgência, voltarei a utilizar este serviço.		
Emoções (EM)	H4 e H5	Vinagre & Neves, 2008.
EM1- A emoção predominante durante o processo de atendimento e tratamento foi:		
a)Interesse b)Prazer d)Angústia d)Medo e)Desgosto f)Vergonha g)Indiferença		
Características dos Pacientes (CA)		Baker, 1996; Wellstood, Wilson, & Eyles, 2005; Fiscella & Franks, 1999.
CA1- Sexo:__Feminino __ Masculino	CA4- Rendimento médio bruto mensal:	
CA2- Idade: __ Anos	__Sem Rendimentos	
CA3- Nível de Escolaridade:	__Até 250 euros	
__ Não sabe ler nem escrever	__Entre 251 e 750 euros	
__ Entre o 1º ano e o 4º ano	__Entre 751 e 1500 euros	
__ Entre o 5º ano e o 9º ano	__Superior a 1500 euros	
__ Entre o 10º ano e o 12º ano	CA5-Cor da pulseira atribuída na triagem:	
__ Ensino superior completo	_Branca | _Azul | _Verde | _Amarela _Laranja | _Vermelha	

Appendix B – PRISMA

Appendix B – PRISMA. (Adapted from Moher, D. et al., 2009)

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

Appendix C - JBI levels of Evidence

Appendix C - JBI levels of Evidence (Adapted from Joanna Briggs Institute, 2013)

JBI levels of Evidence are score from 1 to 5 in which:

1. Experimental Designs:
    a. Systematic review of Randomized Controlled Trials (RCTs);
    b. Systematic review of RCTs and other study designs;
    c. RCT;
    d. Pseudo-RCTs.
2. Quasi-experimental Designs:
    a. Systematic review of quasi-experimental studies
    b. Systematic review of quasi-experimental and other lower study designs;
    c. Quasi-experimental prospectively controlled study;
    d. Pre-test – post-test or historic/retrospective control group study.
3. Observational- Analytic Designs:
    a. Systematic review of comparable cohort studies;
    b. Systematic review of comparable cohort and other lower study designs;
    c. Cohort study with control group;
    d. Case – controlled study;
    e. Observational study without a control group;
4. Observational – descriptive studies:
    a. Systematic review of descriptive studies;
    b. Cross-seccional study;
    c. Case series;
    d. Case study.
5. Expert Opinion and Bench Research:
    a. Systematic review of expert opinion;
    b. Expert consensos;
    c. Bench research/ single expert opinion (Adapted from Joanna Briggs Institute, 2013).

Appendix D - Characteristics of included studies investigating the impact of ED crowding on Patient Experience

Appendix D - Table 4.1. Characteristics of included studies investigating the impact of ED crowding on Patient Experience. (Self-elaboration based in the systematic literature review).

Ref.	Measures/ Scales	Objectives	Methodology	Results	Duration/ Follow-up	Level of evidence	Summary of findings/ conclusion
Wang et al. 2017 USA.	ED crowding scale: - NEDOCS; - SONET; - Patient perception of crowding surveys (patient was asked to rate their perception of relative ED crowding on a Likert scale of 1–10 with 1 being the least crowded. - To align ED crowding scores, results of the surveys were further categorized into the same three levels used to derive SONET as previously reported (i.e. not crowded = 1–5, crowded = 6–7	To evaluate the associations between real-time overall patient satisfaction and ED crowding as determined by patient perception and crowding estimation tool score in a high-volume ED.	A prospective observational study was developed in a tertiary acute hospital academic ED and a level 1 trauma centre. First objective: attribute ED crowding score to each patient upon patient arrival and registration at ED; Second step: simultaneously collect patient satisfaction from real-time patient surveys upon their individual dispositions. For the association between ED crowding and patient satisfaction there were used logistic regression models with estimate odds	This study enrolled 1345 participants. It was observed considerable agreement between the NEDOCS and SONET assessment of ED crowding (bias = 0.22; 95% limits of agreement (LOAs): −1.67, 2.12). However, agreement was more variable between patient perceptions of ED crowding with NEDOCS (bias = 0.62; 95% LOA: −5.85, 7.09) and SONET (bias = 0.40; 95% LOA: −5.81, 6.61). Compared to not crowded, there were overall inverse associations between ED crowding and patient satisfaction (Patient perception OR = 0.49, 95% confidence limit (CL): 0.38, 0.63; NEDOCS OR = 0.78, 95% CL: 0.65, 0.95; SONET OR = 0.82, 95% CL: 0.69, 0.98).	From November 29th 2015 to January 11th 2016	3.e.	While heterogeneity exists in the degree of agreement between objective and patient perceived assessments of ED crowding, it was observed in this study that higher degrees of ED crowding at admission might be associated with lower real-time patient satisfaction.

	and severely crowded = 8–10). Triage scale: - ESI Outcome measures: - Patient real-time satisfaction. Survey: - *Qualitick, clearwater, FL*: patient real-time satisfaction surveys. - Linkert scale (1-10, 1: very dissatisfied).		ratios (ORs) and corresponding 95% confidence limits (CLs) Patient satisfaction scores were transformed from the original scale of 1 to 10, to a continuous 0 to 1 data element.				
Tekwani et al. 2013 USA.	ED crowding scale: - EDOR - EDWIN (ED work index): number of patients and acuity, number of physicians on duty and total bed availability. The higher the EDWIN more crowded the ED. Manageable ED= EDWIN <1.5 Busy ED = 1.5 < EDWIN < 2	to evaluate the impact of ED crowding on patient satisfaction in patients discharged from the ED.	A Retrospective, cohort study of all patients discharge from ED in a teaching hospital and completed Press-Ganey patient satisfaction surveys. It was recorded all mean satisfaction scores and obtained mean ED occupancy rate, mean emergency department work index (EDWIN) score	A total of 1591 surveys were returned. Mean satisfaction score was 77.6 (standard deviation [SD] ±16) and mean occupancy rate was 1.23 (SD ± 0.31). The likelihood of failure to meet patient satisfaction goals was associated with an increase in average ED occupancy rate (odds ratio [OR] 0.32, 95% confidence interval [CI] 0.17 to 0.59, $P <$ 0.001) and an increase in	From August 1st, 2007 to March 31st, 2008	3.e.	Crowding, as measured by EDOR and EDWIN score, was significantly associated with reduced patient satisfaction. Although causative attribution was limited, this study suggested yet another negative impact resulting

	Crowded >2. - Hospital diversion status (Ambulance diversion, status where administration informs its emergency medical services that the hospital is full). Triage Scale: - ESI (EDWIN assigned values to triage score- e.g. ESI-1 as 5, which corresponds to higher severity patients). Outcome measures: - Patient satisfaction. Survey: - Press-Ganey survey: selects patients randomly to distribute surveys, using a read-skip methodology. The system reads the first patient record, then skips the next 7 records, then		and hospital diversion status over each 8-hour shift from data archived in ED's electronic tracking board. Each patient was asked to designate his or her time of arrival: $7:00_{AM}$-$3:00_{PM}$; $3:00_{PM}$-$11:00_{PM}$; $11:00_{PM}$-$7:00_{AM}$. Univariate and multivariate logistic regression analysis was calculated to determine the effect of ED crowding and hospital diversion status on the odds of achieving a mean satisfaction score ≥ 85, which was the patient satisfaction goal set forth by this ED administration.	EDWIN score (OR 0.05, 95% CI 0.004 to 0.55, $P = 0.015$). Hospital diversion resulted in lower mean satisfaction scores, but this was not statistically significant (OR 0.62, 95% CI 0.36 to 1.05). In multivariable analysis controlling for hospital diversion status and time of shift, ED occupancy rate remained a significant predictor of failure to meet patient satisfaction goals (OR 0.34, 95% CI 0.18 to 0.66, $P = 0.001$).			from ED crowding. Although hospital diversion status was correlated with a slight decrease in patient satisfaction goals, this was not clinically significant.

	reads the next record, then skips the next 7 records, until a maximum of 2000 patients is reached each month (40%). - 5-point Likert scale: score of 1 corresponding to "very poor" and a score of 5 to "very good". Each score was converted to mean satisfaction (1=0; 2=25; 3=50%; 4=75; 5=100%).						
Pines et al. 2008 USA.	ED crowding measures: - Patient-level crowding exposures: • Waiting time; • ED treatment time; • Boarding time. - Hallways placement; - ED crowding exposures: • EDOR;	To study the association between factors related to ED crowding and patient satisfaction.	A retrospective cohort study of all patient admitted through the ED who completed Press-Ganey patient satisfaction surveys over a 2-year period at a single academic centre. Ordinal and binary logistic regression was used to study the association between	A total of 1,501 hospitalizations for 1,469 patients were studied. ED hallway use was broadly predictive of a lower likelihood of recommending the ED to others, lower overall ED satisfaction, and lower overall satisfaction with the hospitalization ($p < 0.05$). Prolonged ED boarding times and prolonged treatment times were also predictive of lower	From July 1st 2006 to June 30th 2007	3.e.	A poor ED service experience as measured by ED hallway use and prolonged boarding time after admission are adversely associated with ED satisfaction and predict lower satisfaction with the entire

	• number of admitted patients; • patient-hours; • recent LOS for admitted patients; • waiting room number of patients. Outcome measures: - Patient ED satisfaction: first it was used the degree to each a patient would recommended the ED to others on a 5-point scale and then the average of the three remaining questions. - Inpatient satisfaction: there were used three questions: overall staff coordination; recommendation and overall hospital care. Survey: - Press-Ganey survey; - required satisfaction in both		validated ED crowding factors (hallway placement, waiting times, and boarding times) and patient satisfaction with both ED care and assessment of satisfaction with the overall hospitalization.	ED satisfaction and lower satisfaction with the overall hospitalization ($p < 0.05$). Measures of ED crowding and ED waiting times predicted ED satisfaction ($p < 0.05$), but were not predictive of satisfaction with the overall hospitalization.			hospitalization. Efforts to decrease ED boarding and crowding might improve patient satisfaction.

	the ED and Inpatient area; - Five questions: registration, nursing staff, physician staff, explanation regarding delays and overall recommendation about ED. - 5-point Likert scale.						
Pines et al. 2007 USA.	ED crowding measures (recorded in time of survey administration): - total LOS of every patients in hours; - EDOR - number of admitted patients (inpatients still in ED); - number of ED patients; - number of nurses in ED. Outcome measures: - Patient perception; - Nurses perception; - Doctors perception; Survey:	To measure the association between ED crowding and patient and provider perceptions about whether patient care was compromised.	A cross-sectional study of patients admitted from the ED and their providers. Surveys of patients, nurses, and resident physicians were linked. The primary outcome was agreement or strong agreement on a five-item scale assessing whether ED crowding compromised care. Logistic regression was used to determine the association between the primary outcome and	Of 741 patients approached, 644 patients consented (87%); 703 resident physician surveys (95%) and 716 nursing surveys (97%) were completed. A total of 106 patients (16%), 86 residents (12%), and 173 nurses (24%) reported that care was compromised by ED crowding. In 252 cases (35%), one or more respondents reported that care was compromised. There was poor agreement over whose care was compromised. For patients, independent predictors of compromised care were waiting time (odds ratio [OR], 1.05 for each	Five weeks, winter of 2006	4.b	ED crowding is associated with perceptions of compromised emergency care. There is considerable variability among nurses, patients, and resident physicians over which factors are associated with compromised care, whose care was compromised, and how care was compromised.

	- on a five-item scale assessing whether ED crowding compromised care; - in more questions about how do they perceive crowding compromise care.		measures of ED crowding. The second outcome is a survey in more questions about how do they perceive crowding compromise care.	additional 10-minute wait [95% confidence interval {CI} = 1.02 to 1.09]) and being surveyed in a hallway bed (OR, 2.02 [95% CI = 1.12 to 3.68]). Predictors of compromised care for nurses included waiting time (OR, 1.05 for each additional 10-minute wait [95% CI = 1.01 to 1.08]), number of patients in the waiting room (OR, 1.05 for each additional patient waiting [95% CI = 1.02 to 1.07]), and number of admitted patients waiting for an inpatient bed (OR, 1.08 for each additional patient [95% CI = 1.03 to 1.12]). For residents, predictors of compromised care were patient/nurse ratio (OR, 1.39 for a one-unit increase [95% CI = 1.09 to 1.20]) and number of admitted patients waiting for an inpatient bed (OR, 1.14 for each additional patient [95% CI = 1.10 to 1.75]).			

Appendix E - Characteristics of included studies investigating the impact of ED crowding on Hospital Performance

Appendix E - Table 4.2. Characteristics of included studies investigating the impact of ED crowding on Hospital Performance. (Self-elaboration based in the systematic literature review).

Ref.	Measures/ Scales	Objectives	Methodology	Results	Duration/ Follow-up	Level of evidence	Summary of findings/ conclusion
Stephens, A. and Broome, R. 2019 Australia.	ED crowding scale: - EDOR a measure of occupancy was assigned to each ED record hourly. Outcome measures: - ED waiting time in comparison with recommended time in accordance to the triage attributed priority level; - unplanned readmissions within 28 days; - LOS when admitted.	To assess the association between ED crowding and relevant outcomes including: ED waiting times, rates of admission and representation and LOS when hospitalized.	Retrospective study in New South Wales, Australia, (N = 935 282). ED data were linked longitudinally and cross-sectionally to hospital admissions data. The study outcomes were analyzed multivariable general linear and binary logistic regression models.	Increased ED occupancy was associated with increased ED waiting times (e.g. rate ratio = 2.22, 95% confidence interval [CI] [2.10–2.35], for non-urgent triaged patients). As results were conditional on triage category, effects were smaller or not significant in emergency and resuscitation triaged patients (e.g. rate ratio = 1.59, 95% CI [1.52–1.65], for emergency patients). ED occupancy only showed small or no associations with	From January 1st to December 31st 2015	3.e.	Higher ED occupancy was associated with increased waiting times conditional on triage category and baseline occupancy. EDs are robust and are currently able to absorb fluctuations in occupancy by prioritizing treatment for the most urgent patients.

				unplanned admission within 28 days and LOS when admitted.			
Ugglas et al. 2020 Sweden.	Crowding scale: - Bed Occupancy: measured hourly. ED visits were categorized into groups: in 5% intervals between 85% and 105%. Outcome measure: - Mortality within 30 days; - Inhospital mortality - Unplanned readmission within 30 days of hospital discharge; - Unplanned readmission within 7 days of being discharge; - LOS.	To evaluate the importance of hospital bed occupancy for 30-day mortality, inhospital mortality, readmission for inpatient care within 30 days and revisits to the ED within 7 days among patients visiting the ED.	An observational cohort study. Adult patients visiting 6 EDS in Stockholm Region. Information was extracted from the electronic health care records system. A proportional hazards models was used to estimate adjusted hazard ratios with 95% confidence intervals. Included: patients aged 18 years old with a personal Swedish personal identity. A total of 816,832 patients with 2, 084,554 visits were included.	Mean hospital Bed Occupancy was 93.3%. In total 28,112 patients died within 30 days and 17,966 patients died inhospital. Hospital Bed Occupancy was not associated with 30-day mortality or inhospital mortality. Patients discharged from the EDOR levels greater than 89% had 2 % to 4% higher risk of readmission to the ED within 7 days. A 10 % increase in hospital bed occupancy was associated with 16-minute increase in ED LOS and 1.9% decrease in admission rate.	From 2012 to 2016.	3.e.	It was found an association between increasing hospital bed occupancy and a longer LOS, a higher risk of readmission to the ED within 7 days and a declined in admission rate to inpatient care, which both increase the workload in ED. It was not found an association between increasing hospital bed occupancy and mortality in the sample of this study.

Chiu et al. 2018 Taiwan.	ED crowding scale: - EDOR: grouped into four quartiles, and analyzed in reference to the clinical practice. Triage Scale: - TTAS (determined based on patient initial vital signs and chief complains, 5 levels, recommended: immediately, 10, 30, 60 and 120 minutes for resuscitation, emergent, urgent, semi-urgent and non-urgent). Quality measures: - Efficiency: Decision-making time (time interval between the patient registration and the EP completing the disposition decision) and LOS (until patient leaves);	To clarify the association between the crowding and clinical practice in the ED.	A retrospective cohort study conducted in two EDs in Taiwan included 70,222 adult non-trauma visits during the day shift. To describe the association between efficiency and ED crowding it was used Kruskal-Wallis test. To analyze the association between all quality measures and ED crowding: multinomial logistic regression for patient disposition with disposition of discharge as dependent variable and binomial logistic regression for diagnostic tool use. It was used 95% of confidence intervals. Significance testing was two-sided, and the significance threshold was set at $P < 0.05$. SPSS version 12.0 was used for statistical analyses.	The four quartiles of ODOR were < 24, 24–39, 39–62, and N=62. Comparing N=62 and > 24 EDOR, the physicians' decision-making time and patients' LOS increased by 0.3 h and 1.1 h, respectively. The percentage of patients discharged from the ED decreased by 15.5% as the ED observation, general and intensive care unit admissions increased by 10.9%, 4%, and 0.7%, respectively. CT and laboratory examination slightly increased in the fourth quartile of EDOR.	From July 1st 2011 and June 30th 2012.	3.e.	ED Crowding might increase physicians' decision-making time and patients' LOS, and more patients could be admitted to observation units or an inpatient department. The use of CT and laboratory examinations would also increase. These could lead more patients to stay in the ED.

	- Patient disposition: ED discharge, ED observation, general admission, Intense Care Unit (ICU) admission and ED mortality; - ED diagnostic tool use: use of laboratory examinations and computed tomography (CT).						
Bergs et al. 2014 Belgium	ED crowding scale: - EDOR – first hour of attendance, starting from time registration. Recorded every 10 minutes by hospital's computer system. Triage Scale: - ESI level 1 and 2: recommended waiting time 10 and 30 minutes. Considered unsafe if longer tan 10 and 30 minutes respectively. Outcome measures:	To investigate whether the number of patients simultaneously present at the ED might be an indicator of unsafe waiting and at what threshold hospital-wide measures to improve patient outflow could be justified.	A retrospective study. ED patients aged >16 years, and triaged as ESI-1 or ESI-2 were eligible for inclusion. The obtained data was descriptively analyzed using the median and interquartile range (IQR). Differences in waiting time and occupancy between patients with safe and unsafe waiting times were analyzed using the Mann–Whitney U test. The ability of EDOR to discriminate unsafe	The overall median waiting time was 5 min (IQR = 4–8) for ESI-1, and 12 min (IQR = 6–24) for ESI-2 patients. Unsafe waiting times occurred in 16.0% of ESI-1 patients (median waiting time = 17 min, IQR = 13–23), and in 18.9% of ESI-2 patients (median waiting time = 48 min, IQR = 37–68). The ODOR was a weak indicator for unsafe waiting times in ESI-1 patients	From January 1st 2012 to December 31st 2012	4.b.	ED Crowding affects waiting times and it is a moderate indicator of unsafe waiting time. Future initiatives to improve safe waiting times should not focus solely on occupancy, and expand their focus towards other factors affecting waiting time.

	- waiting times in comparison with recommended time in accordance to the triage attributed priority level.		waiting times was analyzed using a receiver operating characteristic curve (ROC). All P values were two-sided, and statistical significance was set at a P value of less than 0.05. All analyses were performed with the R statistical software package (version 2.15.1).	(AUC = 0.625, 95% CI 0.537–0.713) but a fair indicator for unsafe waiting times in ESI-2 patients (AUC = 0.740, 95% CI 0.727–0.753) for which the threshold to predict unsafe waiting times with 90% sensitivity was 51 patients.			
O'Connor et al. 2014 Canada.	Crowding measure: - EDOR – > 1.5 Triage scale: - CTAS: waiting time recommended: immediately, 10, 30, 60 and 120 minutes for resuscitation, emergent, urgent, semi-urgent and non-urgent); Outcome measure: - DTDT	To determine if ED crowding influenced patient triage destination and intensity of investigation, as well as rates of unscheduled returns to the ED. Authors focused on patients, triaged as high acuity	A Retrospective cohort study was developed in two ED campuses of large urban tertiary care Canadian academic teaching hospital with approximately 75,000 patients visits per year. A health records review of patients presenting in these two EDs was developed. A total of 4,234 patients' visits were identified.	500 health records were studied. When ED was crowded: CTAS score of 2 were triaged more often, DTDT was longer (107.3 – 76.0 minutes) and high acuity patients presenting with chest pain or shortness of breath had a higher rate of triage to the non-	From January 1st to December 31st 2010	3.e.	During crowded conditions, high acuity patients presenting with chest pain or shortness of breath had a higher rate of triage to the non-monitored area of the ED and longer DTDT. It was not possible to detect a

	- Unplanned readmission within 14 days	(presenting with chest pain or shortness of breath), and who were subsequently discharged home.	Included: patients older than 18 with either chest pain or shortness of breath assign with a triage score 2 (emergent: DTDT recommended is 15 minutes).	monitored area of the ED (25.5% - 16.3%) Rates of unscheduled returns were not associated with ED crowding.			difference in rates of unscheduled returns to ED. Future research: examining these changes during crowded conditions and patient outcomes.

Appendix F - Characteristics of included studies investigating the impact of ED crowding on Patient Experience and Hospital Performance

Appendix F- Table 4.3. Characteristics of included studies investigating the impact of ED crowding on Patient Experience and Hospital Performance. (Self-elaboration based in the systematic literature review).

Ref.	Measures/ Scales	Objectives	Methodology	Results	Duration / Follow-up	Level of evidence	Summary of findings/ conclusion
Mullins and Pines 2014 USA	ED crowding scale: - median LOS for inpatients (IPLOS); - median LOS for discharge patients; - Boarding time; - DTDT; - LWBS. Outcome measures: - LWBS; - Readmission rates; - Complications: Acute Myocardial Infraction (AMI), healthcare-associated infections, Hospital- acquired Condition (HAC) and pneumonia; - Outpatient imaging efficiency; - 30-day mortality; - Patient Experience.	To assess characteristics of reporting vs non-reporting hospitals. To compare ED performance in ranked and unranked hospitals and assess relationships between ED crowding and reported hospital quality measures. To assess possible effects of educating	An exploratory investigation of Hospital Compare's ED crowding measures, using data from downloadable Hospital Compare data files (from January 1st and June 30th, 2012) about KPIs and "top-ranked hospitals" (2012-2013) and data from Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) patient surveys (2008-2012). Authors explored Hospital Compare data on emergency department (ED) crowding metrics. US News Best Hospitals.	Of 4810 hospitals included in the Hospital Compare sample, 2990 (62.2%) reported all ED 5 crowding measures. Median IPLOS was 262 minutes (interquartile range [IQR], 215- 326), median boarding time was 88 minutes (IQR, 60-128), median LOS for discharged patients was 139 minutes (IQR, 114-168), and median DTDT was 30 minutes (IQR, 20-44). Higher LOS was associated with lower patient satisfaction (patient reported hospital as 9 or 10 r= - 0.23, p< .001). LWBS is adversely associated with the percentage of patients that would recommended the ED (r= - 0.14, P < .001). Hospitals ranked as US News Best Hospitals 2012 to 2013	From 2008 to 2013	3.e.	ED crowding was associated with lower patient satisfaction, with higher rates of HAC, and higher unplanned readmission rates. There is great variation in measures of ED crowding across the United States of America. Emergency department crowding was related to several measures of in-patient quality – LOS, LWBS, unplanned readmission rates

		medical students and residents on ED crowding.	To examine relationship between ED crowding measures and quality measures it was calculated Spearman rank correlation coefficients. To examine potential associations between ED crowding and teaching and non-teaching and ranked and non-ranked hospitals, it was used Mann-Whitney U tests.	(n = 650) reported poorer performance on ED crowding measures than unranked hospitals (n = 4160) across all measures. Emergency department boarding times were associated with unplanned readmission rates for AMI (r = 0.14, P b .001) and pneumonia (r = 0.17, P b .001) as well as healthcare-associated infections (r = 0.37, P < .001).			and HAC, which suggests that ED crowding should be a hospital-wide priority for quality improvement efforts.
Vieth and Rhodes 2006 USA	ED crowding scale: - LWBS; - Providers rates of crowding. Triage system: - patient is classified into 1 of 5 institution- defined acuity categories. - Red are emergent patients requiring immediate treatment. - For non-emergent patients: patients	To evaluated ED access and provider and patient assessments of quality.	A multimethod study developed in an urban academic ED, included descriptive analysis of administrative records, provider surveys, and patient surveys. Providers survey – during each shift at 6-hour interval the attending physician and charge nurse simultaneously rated the level of ED crowding (from busy:	During data collection periods, 11 743 patients registered, and 9% LWBS. Patients who LWBS tended to be younger than 45 years (relative risk [RR] = 1.7; 95% [CI], 1.5-1.9), of non-urgent/stable triage acuity (RR = 3.1; 95% CI, 2.5-3.8), and without insurance (RR = 1.5; 95% CI, 1.3-1.7). 74% of all patients had insurance, and 28% were private.	Data were gathered from 4 sample periods in 2003 for a total of 13 weeks.	4.b.	ED crowding increased LWBS and decreased patient satisfaction. ED crowding restricts access to ED and compromises the quality of care as perceived by patients and providers.

	with a potentially unstable condition are placed in the yellow category requiring treatment in less than 2 hours and with stable conditions are orange category; - Non-urgent are categorized as green or blue (if very minor non-urgent cases. Outcome measures: - LWBS rate; - Provider perceived quality of care; - Patient satisfaction. Surveys: - paired physician and nurse provider surveys; - pre- (in the waiting room) or post- (phone call 1 week after ED visit) patient surveys regarding expectations and experiences;		1 to extremely busy: 5) and perceived effect on patient care (from strongly disagree: 1 to strongly agree: 5). The average ED crowding rating of the 2 providers was correlated with LWBS rate during the subsequent 6 hours. It was used a weighted Cohen's k calculation to test agreement on crowding and compromised care. Providers were considered in close agreement if they selected within 1 point of each other Patient survey - there were enrolled patients arriving after 4:00 pm once LWBS rate is higher in the evening. Patients who LWBS were asked whether they had sought alternative care, or their problem had resolved without	Doctors and nurses had 81% agreement (j = 0.54) in their assessment of crowded conditions, which were temporally associated with LWBS rates (P < .01). In 47% of 57 shifts, at least 1 provider felt that crowding was compromising quality of care. Of 423 sequential ED waiting room patients approached, 310 (73%) enrolled and 174 (56%) of these completed phone follow-ups. On average, patients felt that they should be seen within 1 hour but expected to wait for 2.1 hours. Patient's perceived that wait times on follow-up averaged 3.5 hours, 5+ hours for LWBS patients. ED satisfaction was inversely related to patient's perceived wait times.			System wide changes in ED organization, it will be necessary for the ED to fulfil its role as a safety net provider and meet public health needs during disaster surge capacity.

	- 5-point Likert scale.		treatment and how long they waited before LWBS, what were their reasons for leaving, and what might have prevented their leaving. Patients who remained for treatment were asked what their waiting times had been, along with an assessment of quality, satisfaction, problem resolution, and adherence to recommended follow-up. Patient surveys was analyzed descriptively with percentages and means. There were used *t* tests and X^2 tests. Statistical analyses were performed using Stata 7.0.				