Chapter 3
Decades Trend of Emergency Department System Operations

Salman Ben Zayed, Abdullah Bin Gani, Hesham Fathy Gadelrab, and Mohd Khalit Bin Othman

Abstract Emergency services are meant to ensure the timely delivery of essential healthcare services to people using complex systems. If emergency services use real-time patient information to select the most suitable emergency option, it will allow the service provider to more quickly conduct a detailed physical examination to diagnose the problem and to determine a treatment plan that will suit the patient. Emergency departments offer various services and have several components that are conducted under complex management. This study examined previous research on engineering systems and the evaluation of the quality of healthcare systems. These studies considered the level of patient satisfaction and investigated how healthcare is influenced by operational management. The research also indicated that real-time data are very helpful for mangers in emergency departments to help them make appropriate decisions. This finding implies that patient satisfaction can be ensured through the extraction of data about the issues related to proper, operational, and effective management. Patient satisfaction and the quality of services and care delivered can be enhanced to improve the patient's overall experience by using development strategies and quality evaluation in EDs. The previous research conducted on the management and processes of emergency departments was systematically reviewed and classified. This study reviewed research conducted between 2000 and

S. Ben Zayed (✉) · A. B. Gani (✉)
Department of Computer System and Technology, Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur 50603, Malaysia
e-mail: szharthi@uqu.edu.sa

A. B. Gani
e-mail: abdullah@um.edu.my

H. F. Gadelrab
Measurement, Evaluation and Statistics, Kuwait University, Kuwait, Kuwait

M. K. Bin Othman
Department of Information System, Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur 50603, Malaysia

S. Ben Zayed et al., *Operational Management in Emergency Healthcare*, Studies in Systems, Decision and Control 297,
https://doi.org/10.1007/978-3-030-53832-3_3

2019 to understand how emergency departments used processes, addressed issues, and resolved issues when considering the patient in an ideal healthcare setting with a high standard of operation management. Emergency services are significant for everyone because anyone may need these services at any time. This study uses the data from the last 20 years to investigate the methods employed during that time in emergency department operations.

Keywords Emergency · Management · Preparedness · Quality · Engineering · Healthcare and systematic review

3.1 Introduction

The introduction of new tools and performance evaluation systems in EDs in underdeveloped countries resulted in a positive impact on the measurement of the quality of care and services delivered to patients. In particular, the patient's perspective is considered in this kind of performance evaluation. The process of evaluating the efficiency of the facilities and the services offered by an ED is complex, and there is no specific theoretical formula for this evaluation. The supervising system and functional strategies that serve as criteria for evaluating the efficiency of any ED's facilities are not presently implemented in developing and underdeveloped countries, which makes it difficult to evaluate the performance of ED facilities in these countries. When considering technology, such countries can use factors that ensure a high standard observational system for an emergency department as criteria for evaluating emergency medical services.

The operational management of an emergency department is a complex job and involves various complicated factors. Quick and immediate responses to patient queries must be provided through effective strategies. The main prevailing issue in EDs is the attentiveness of the emergency staff and the readiness of the processes, which allow smooth operations and prevent prolonged waiting and overcrowding in the case of catastrophic events. Overcrowding may also occur with higher casualties, readmissions and when patients cannot see the doctor because of prolonged wait times. Moreover, since all kinds of patients with minor to major illness come to the emergency department, the patients must be categorized on the basis of the severity of their condition so that the more serious patients can be treated first to prevent them from being deprived of the timely services and care they need. The treatment process involves a patient's admission, examination by the doctor and provision of a suitable treatment.

The available research was explored to detect the correspondence between the search systems and data collection [1–3]. Emergency departments (EDs) impart emergency services to patients in urgent need of care by providing acute, out-patient care. The evaluation of the technologies used for care and services must be accompanied by a decision-analytic model. The hospitals must make efforts to introduce and improve this technological analysis because it facilitates effective patient-staff

interaction and regulates the procedures involved in patient care. As EDs operate multiple systems and impart multiple services to patients, they may face numerous issues; therefore, it is imperative to conduct system analyses. Although mathematical models have been investigated by numerous studies in the context of healthcare, no work has been conducted to investigate these models in the context of EDs, although the mathematical models could help reduce prolonged wait times in the EDs.

3.2 Background

A critical element of the healthcare system is the emergency department (EDs). EDs serve as a setting in which high-quality, instant care and services are offered to patients by care providers. Typically, EDs face challenges, such as overcrowding and lengthy wait times. These challenges are due to certain demand and supply-side factors that have an impact on the ways in which patients are provided care in various settings. Problems such as overcrowding and extensive wait times can be managed by hospitals when there is adequate planning, staffing, and resource allotment and effective patient management. Furthermore, the examination and assessment of the effect and cost-effectiveness of different interventions and approaches used to address the issues experienced at EDs can be facilitated by mathematical frameworks. It is also important to perform additional evaluations to identify the technologies that can be employed by hospitals to decrease waiting and overcrowding in their EDs.

A large amount of information and data on hospitals are available through the emergency department or patient files, which can be reviewed to facilitate management decision-making [1]. EDs are a critical element of the healthcare system [2]. Typically, these sub departments operate 24-h-a-day so that immediate treatment and care can be offered to patients suffering from extremely critical conditions and illnesses [3]. It is important to enhance ED resources and those of the entire healthcare system.

3.3 Material and Methods

The systematic review employed the approaches mentioned in [1–3]. The review starts with a systematic analysis of the research to classify the studies and create a thematic assessment. The available literature is discussed in detail in this research. The systematic approach presents the outline of the research area and the drawbacks of the research [3]. The most recent sources of data are employed in this research. This study is quite significant because it is focused on the standard of healthcare and contributes to the present literature by investigating the concept of emergency preparedness, system operations and services reengineering in the context of the ED, which has not been previously explored.

3.3.1 Research Questions (RQs)

The systematic review employed the approach in [1–3] to identify the problems faced by operations of the ED system and gave rise to the following questions:

- RQ1: When and where was the research published?
- RQ2: What problems/objectives were addressed in the research?
- RQ3: Which methods were utilized in the ED operations research?
- RQ4: What measurements and KPIs were used?
- RQ5: What were the findings?
- RQ6: What are the shortcoming and deficiencies that were addressed?
- RQ7: What themes were introduced in the ED operations research?
- RQ8: How was the research categorized?

3.3.2 Search for Strings

Databases were searched with the help of international web trends based on the following keywords: emergency department, emergency medical care, emergency clinics, management, preparedness, quality, reengineering, and health care as shown in Figs. 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, and 3.8. The search strings mentioned below were obtained using the search strings:

- Set 1: Search terms related to research on EDs (i.e., emergency department, healthcare).
- Set 2: Search terms related to strings (e.g., emergency medical care and emergency clinics).
- Set 3: Search terms related to themes (e.g., management, preparedness, quality, reengineering).

The keywords were divided into different groups based on the research questions. Table 3.1 shows all of the search strings that were searched in the databases. This

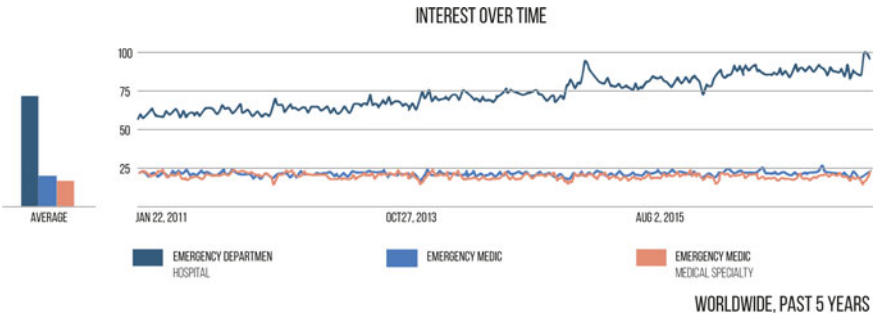


Fig. 3.1 Comparison of EDs three strings worldwide by time

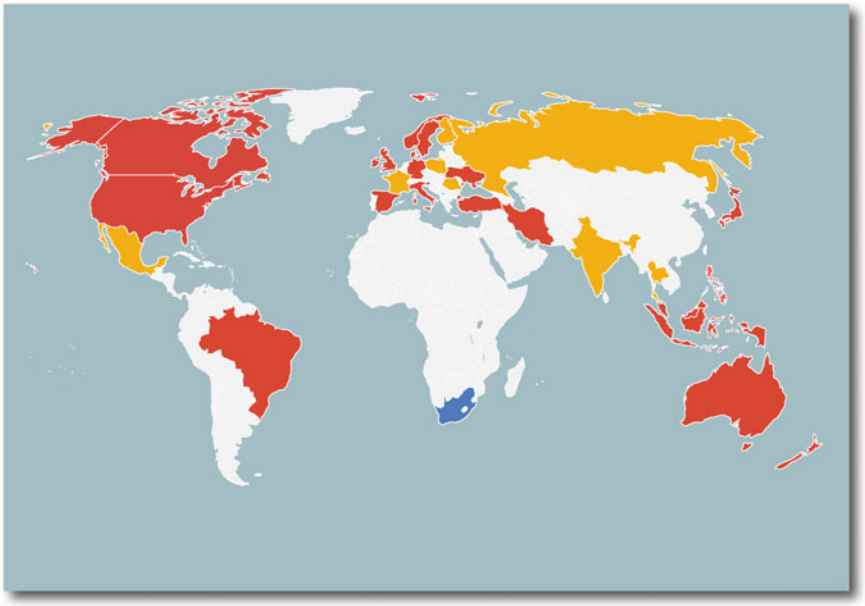


Fig. 3.2 Comparison of EDs three strings worldwide by region

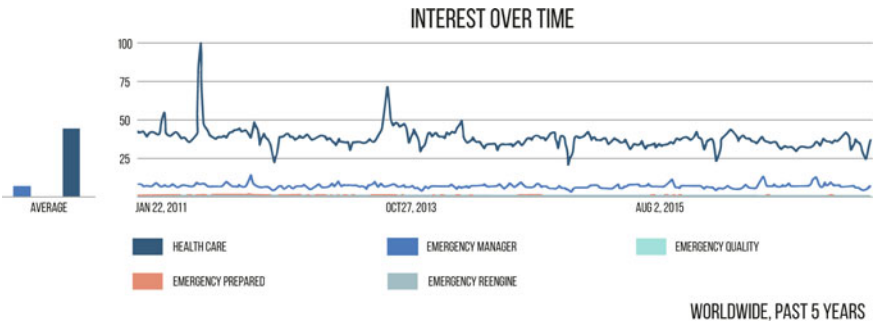


Fig. 3.3 Worldwide trend of EDs other search strings by time

study was classified based on the time it was mined (i.e., from 2018 to 2019). The search results obtained from each database are shown in Table 3.1.

3.3.3 Search for Primary Studies

The search for primary studies was conducted in the following databases. These databases were chosen because they are comprehensive and contain millions of

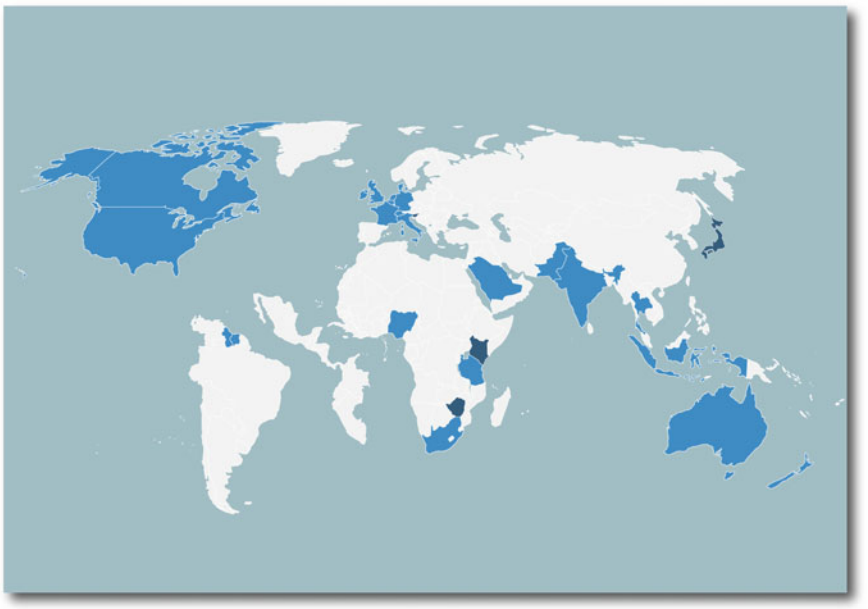


Fig. 3.4 Emergency management worldwide trend by region

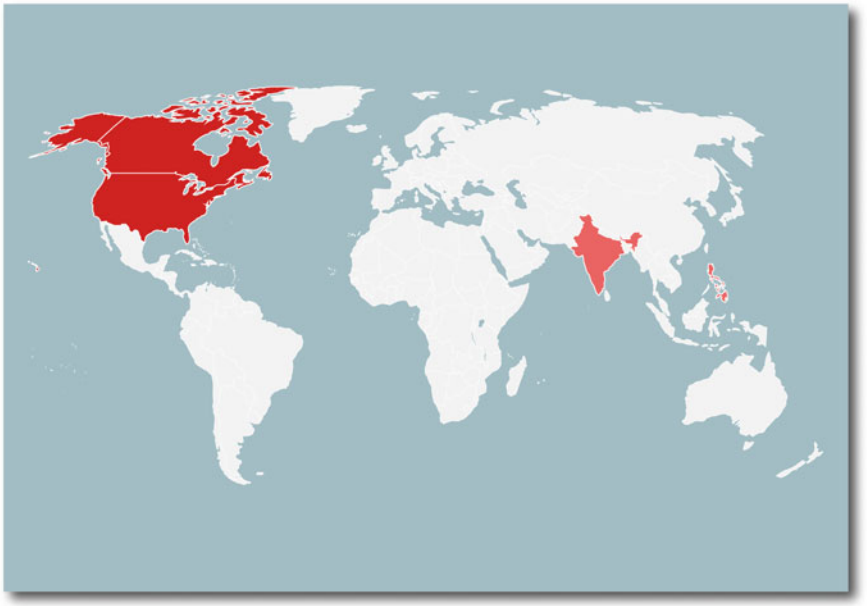


Fig. 3.5 Emergency preparedness worldwide trend by region

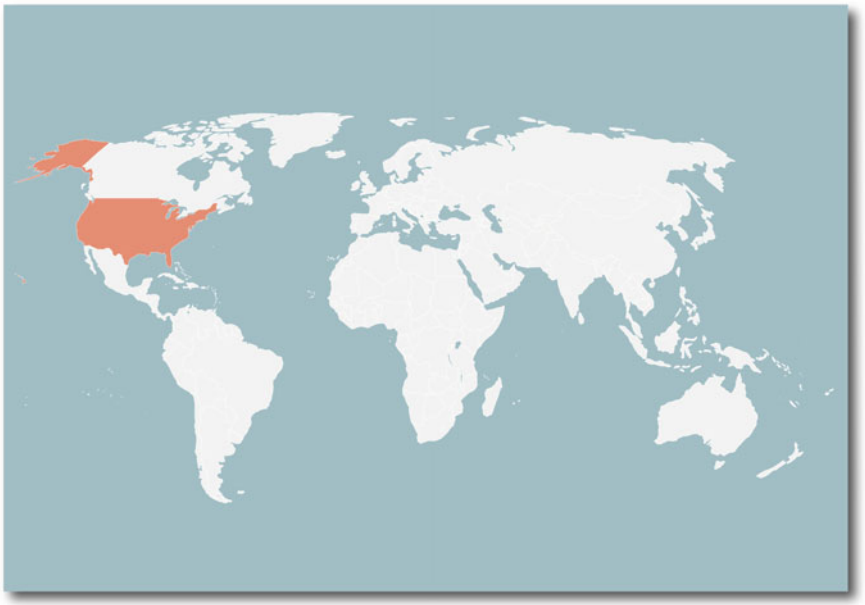


Fig. 3.6 Emergency quality worldwide trend by region

Fig. 3.7 Emergency reengineering worldwide trend by region

publications, especially those related to EDs, engineering, and computer science. Moreover, these databases are user friendly and have advanced search features e.g., IEEE Xplore, ABI Inform, Google Scholar, etc.

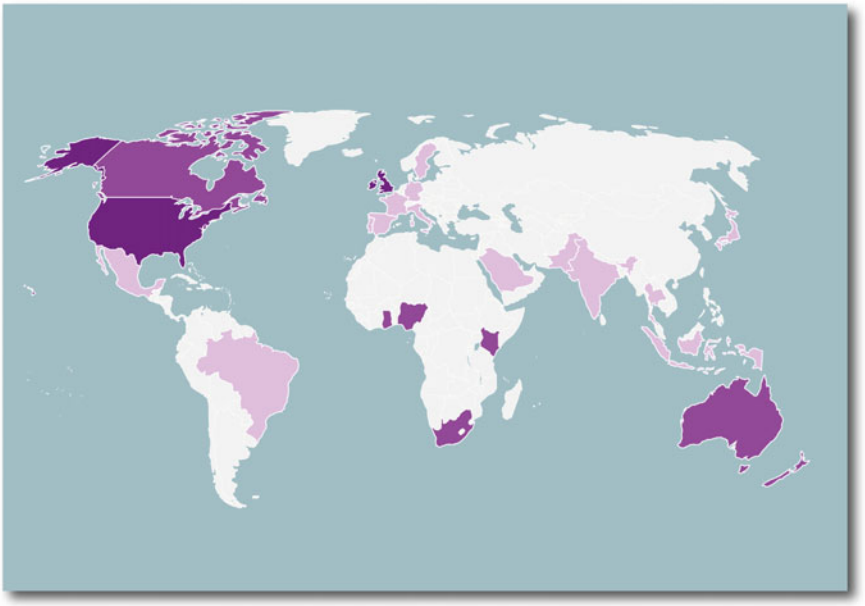


Fig. 3.8 Health care worldwide trend by region

Table 3.1 Search strings

Database	Search strings
1	(Emergency Department OR Emergency Medical Care OR Emergency Clinics) AND (Emergency Management OR healthcare) AND (Emergency Preparedness OR healthcare) AND (Emergency Quality OR healthcare) AND (Emergency Reengineering OR healthcare)
2	(Emergency Department OR Emergency Medical Care OR Emergency Clinics) AND (Emergency Management OR healthcare) AND (Emergency Preparedness OR healthcare) AND (Emergency Quality OR healthcare) AND (Emergency Reengineering OR healthcare)
3	(Emergency Department OR Emergency Medical Care OR Emergency Clinics) AND (Emergency Management OR healthcare) AND (Emergency Preparedness OR healthcare) AND (Emergency Quality OR healthcare) AND (Emergency Reengineering OR healthcare)

Table 3.2 Primary studies

	Search results	Date
Databases	631,957	2000–2019

Fig. 3.9 Study selections process

3.3.4 Study Selections

Figure 3.9 shows that some of the studies were not considered in our study because of certain characteristics of the database. The studies were mainly selected based on their relevance and citations. The studies that did not include proper references or citations were not included. In addition to references, the studies were selected based on the following features: the study must be related to the management, the ED and attentiveness of the ED staff and services, and the quality of healthcare; the study must consider reengineering and healthcare associated with Eds; and the study must have been conducted between 2000 and 2019. Moreover, the selected studies were evaluated and excluded because of the following features: the study did not meet the criteria of full text; the study was not reviewed; the study was a duplicate study, and the study was in a language other than English. Figure 3.9 shows the quantity of the studies that were selected for inclusion and exclusion from the database search. Moreover, Table 3.3 represents the model for studies that required further data extraction for research.

3.3.5 Data Mining

The data obtained was used to present the model given in [1–3]. Table 3.3 shows that the model was customized according to the research requirements. The factors are shown in the table along with their corresponding quantity. One of the experts extracted the data while two others reviewed the data to ensure the validity and

Table 3.3 Data mining table

Item	RQ result	RQ
Study ID	Number	Coding
Author name	Name(s)	Reference
Year of publication	Calendar year	RQ3
Country	Location of research	RQ3
Objective/problem	Problem or objective of research	RQ2
Method	Method used	RQ3
Measurements/KPIs	Items used or measured	RQ4
Findings/conclusions	Result of research	RQ5
Shortcoming/deficiency	Limitation of research	RQ6
Venue	Journal name	RQ7 and RQ8

standard of the mined data. Moreover, another expert evaluated the data for further verification.

3.3.6 Verification and Validation

The data collection procedure followed in this research was highly objective. This data collection method ensures greater validity of the data compared to the quantitative analysis method. The data obtained were recorded in a data-collection Tables 3.1, 3.2 and 3.3 to support the data and to ensure greater validity of data, since tables can be reviewed to evaluating the extracted data. The risk to data validity was reduced to a significant extent due to the involvement of three experts who independently reviewed the data to prevent any risk of invalidation [2]. Therefore, the collected data were found to be accurate and objective with an insignificant degree of risk [1–3].

3.4 Results

In this review, the approaches in [1–3] were used to identify the issues encountered in ED systems operations. Based on these issues, eight research questions were developed.

3.4.1 When and Where Were the Research Published

Several journals that were issued between 2000 and 2019 were included in each database. The earliest study was published in 1998. The importance of this field peaked in 2013 and significantly declined afterwards. The present study considered only peer-reviewed journals, materials, and conferences that answered the research question. The volume of the articles is shown in Fig. 3.10, when researches were published in Fig. 3.11 and where shown in Figs. 3.12 and 3.13. Studies on engi-

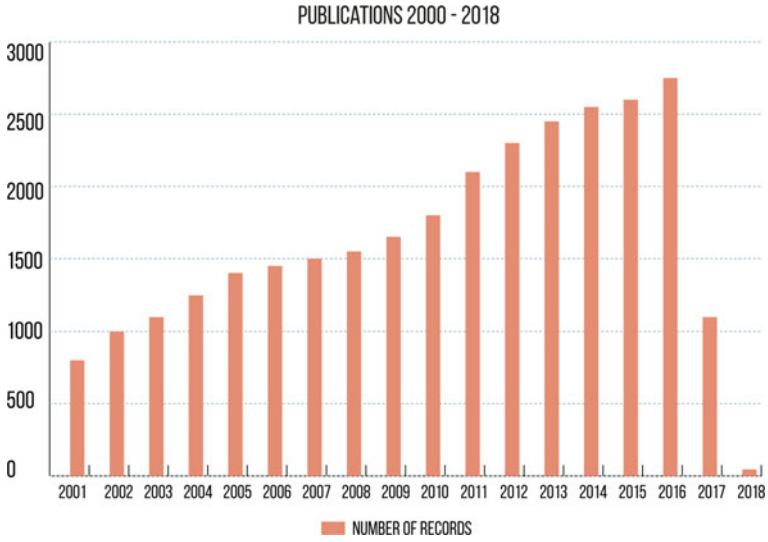


Fig. 3.10 Number of EDs studies per year

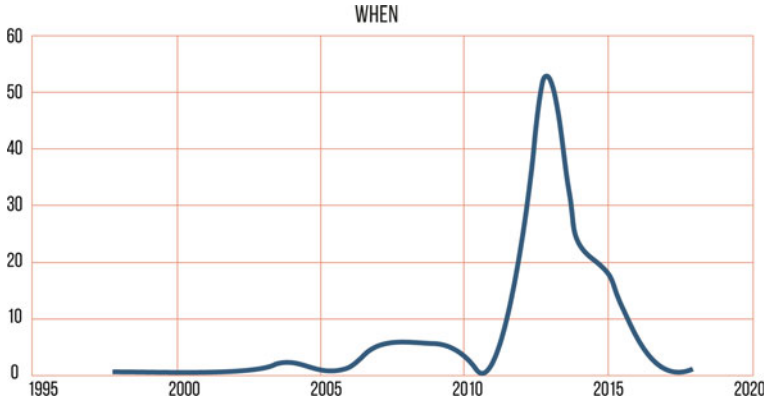


Fig. 3.11 When EDs studies were published

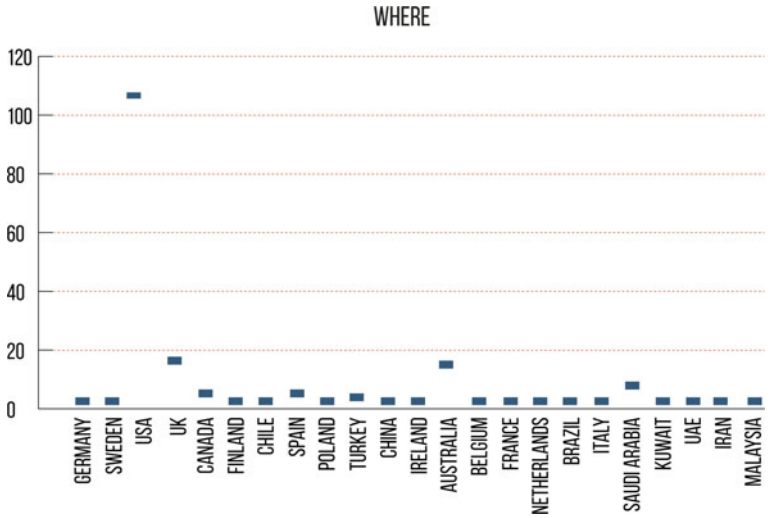


Fig. 3.12 Where EDs studies were published

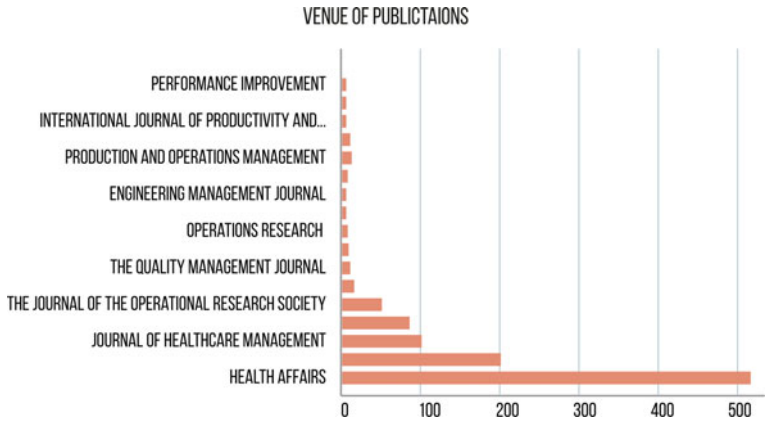


Fig. 3.13 Venue of EDs publications

neering, simulation and process management constituted only 9.92% of the total studies on EDs published from 1998 to 2018.

3.4.2 What Issues Were Addressed in the Research

The current hospital systems need to be removed and replaced with new systems. Not only the systems but also the hospitals themselves, which can be considered systems

Table 3.4 EDs problems

Issue addressed	References
Cost of quality	[41, 83, 87, 109, 111, 112, 133, 137]
Medical data	[41, 44, 51, 67, 89, 126, 130, 139]
Service improvement	[9, 12, 30, 38, 41, 81, 90, 96, 106, 112, 128]
Overcrowding	[26, 27, 51, 57, 58, 125, 144, 145, 148]
Management	[4, 6, 16, 49, 86, 89, 95, 141]
High number of visit	[24, 51, 57, 102, 119, 127, 131, 147]
Waiting time	[5, 9, 12, 19, 27, 48, 113, 126]
Collective skills	[25, 45, 56, 67, 106, 151]

that included separate parts, especially emergency departments, need to be replaced. The issues that arise include the cost of quality, medical data, service improvement, overcrowding, management, high number of visits, wait times and collective skills. Experts are needed to research, explore, and investigate these problems and to improve the processes of service to create a better mechanism and medical reform for each part (Table 3.4).

3.4.3 Methods Were Utilized in ED Operations Research

The data analysis is capable of producing a model that handling services, improves organization, and influences new healthcare. The various number of studies used different approaches that focused not only on patients but also on the healthcare workforce. Various research tools have been utilized mainly including surveys, interviews, observation checklists, questionnaires, and literature reviews. The data used in the studies were either primary or secondary data. The methodologies include analyzing the empirical data, meta-analysis, and simulation. The statistical models utilized include mainly linear regression, logistic regression, correlation, and mean differences.

3.4.4 What Measurements and KPIs Were Used?

Many ED studies tend to measure a wide range of factors in the context of health care within emergency departments. The main key points researchers focus on are health care quality versus the cost of the medical service provided by the system, time spent serving the patient, patient satisfaction, patient length of stay, clinical information, health care services provided to patients, accessibility of the health care system, performance of the health care providers such as physicians.

Table 3.5 EDs data types

Data type	References
Primary	[10, 146]
Secondary	[9, 14, 43, 142, 148, 153]

Table 3.6 EDs studies types

Studies type	References
Empirical	[35, 38, 62]
Observation	[6, 10, 12, 20, 34, 38, 52, 63, 107, 116, 133, 136, 151]
Simulation	[2, 3, 7, 17, 23, 37, 87, 125, 132, 135, 154]
Case study	[9, 89, 151]

3.4.5 What Were the Findings

Quality care is a vital initiative that must be pursued by healthcare providers to affect the high number of visits and the time of services. The implementation of these targeted processes using simulation data to build a significant system will improve services and increase satisfaction for both providers and patients. Therefore, this approach will result in low cost but quality care and an effective emergency system where optimal decisions are made. General findings can be found by looking at Tables 3.5, 3.6, 3.7, 3.8, 3.9, 3.10 and 3.11.

3.4.6 Shortcoming and Deficiencies that Were Addressed

One of the major limitations of ED systems is the availability of accurate data and research. A weak analysis and the wrong tools for analysis will lead to large amounts of incorrect decisions. Errors can be divided into human errors and systems errors. Another issue is data collection during ED research. Very few studies have considered patient characteristics and demographics in their decisions. Observations that are connected and investigations that result in strong evidence provide better information, a strong model and useful information that is exclusive to the ED system. Another deficiency in EDs is traffic including volume, emissions, and noise. A significant number of patients suffer from traffic congestion during their transportation to EDs.

3.4.7 Themes Were Introduced in the ED Operations Research

The classification of themes as shown in Fig. 3.14 shows that there is a general gap

Table 3.7 EDs method types

Method type	References
Interview	[2, 6, 12, 36, 39, 45, 62, 79, 83, 96, 99, 106, 115, 122, 151]
Survey	[3, 13, 31, 37, 68, 72, 80, 82, 83, 92, 96, 105, 106, 108, 116, 118, 126, 128, 141, 143, 146]
Review of literature	[48, 53, 54, 86, 103, 110, 134]
Questionnaire	[6, 38, 45, 46, 104, 120, 146]

Table 3.8 EDs analysis types

Analysis type	References
Meta-analysis	[33, 35, 36, 59, 60, 64, 66, 80, 85, 93–95, 97],
Correlation	[27, 109, 111, 114, 129, 130]
Linear/nonlinear regression	[1, 26, 31, 57, 77, 100, 112, 118]
Logistic/multinomial regression	[32, 34, 132, 152]
Mean differences	[34, 73, 112, 152]

in the knowledge about organizational behavior, performance, and quality of service in healthcare, especially in EDs. A more specific gap is introduced in Fig. 3.15.

3.4.8 How Was the Research Categorized

The volume of all of the studies in this field from 2000–2019 were classified based on venue type, and no dissertations, theses or books were introduced as shown in Figs. 3.16 and 3.17.

3.5 Discussion

The trends of the problems that have existed in healthcare emergency system operations for the past decades include the cost of quality, medical data, service improvement, overcrowding, management, high number of visits, wait times and collective skills.

3.5.1 Emergency System Problems

3.5.1.1 Cost of Quality

The task of improving the efficiency of an elderly patient's treatment is a significant research problem [83]. The Medicare Essential program is presented to improve the effectiveness and efficiency of services [87] and reduce costs. There is a wide variation in admission rates for U.S. hospitalizations due to variations in effectiveness [109]. The Medicare agencies are asked to determine whether for-profit home health agencies are more effective than nonprofit home health agencies [111]. The prices for health care services vary significantly across different hospitals, and experts determine the likelihood of a patients' choice of a lower-price facility based on whether

Table 3.9 EDs KPIs types

KPIs	References
Health care quality	[8, 18, 28, 33, 34, 36, 38, 41, 55, 61, 65, 77, 84, 85, 88, 89, 95, 106, 108, 136, 139]
Medical cost	[3, 33–35, 37, 39, 41, 52, 54, 58, 63, 69, 76, 84, 88, 94, 97, 98, 100, 106–109, 111, 112, 129, 133, 137, 139, 140, 149]
Services' processing time	[7, 15, 17, 19, 20, 24, 27, 44, 51, 116, 117, 120, 122, 126, 144, 145, 148, 149]
Satisfaction	[16, 54, 76, 77, 107, 108, 113, 115]
Length of stay	[6, 24, 49, 52, 78, 114, 145, 148, 154]
Efficiency of ED services	[23, 113, 139, 144]
Access to health care	[106, 114–116, 136]
Performance	[2, 10, 41, 62, 142, 150]
Admission	[6, 34, 52, 102, 107, 109, 119, 124, 125, 133, 140]
Demographic characteristics	[11, 57, 123, 127, 148, 152]

Table 3.10 EDs expected results

Expected result	References
Quality care	[8, 33, 36, 38, 41, 55, 59, 76, 84, 132]
Process simulation	[2, 10, 17, 23, 99, 125, 141]
Good decisions	[43, 58, 65, 69, 80, 98, 108]
Savings	[37, 58, 69, 101]
Improved service	[2, 12, 55, 76]
Better experience	[49, 53, 77, 86, 94, 126, 141]

Table 3.11 EDs shortcoming/deficiency types

Shortcomings and deficiencies	References
Data availability	[11–13, 20, 31, 34, 48, 71, 125]
Errors	[21, 22, 48, 54, 55, 71, 111, 117]
Assumptions e.g., Traffic	[26, 35, 52, 56, 61, 67, 93, 97, 114, 135, 149]
Cost	[37, 41, 69, 111]

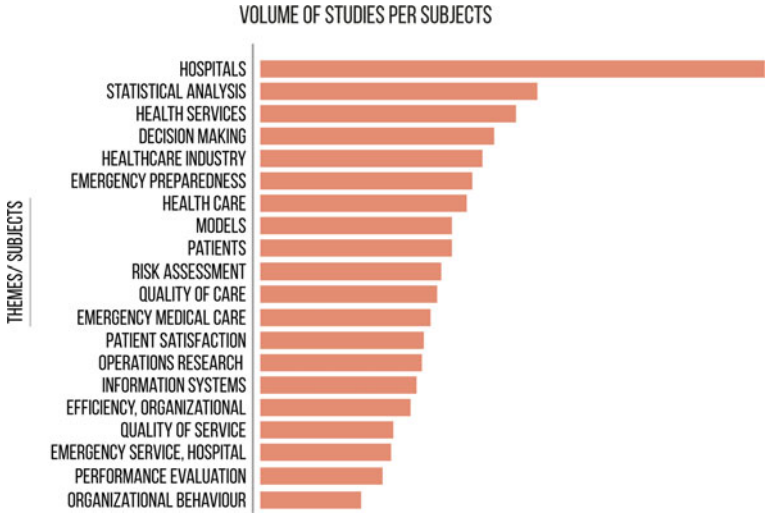


Fig. 3.14 Classifications of EDs studies by themes/subjects before study

or not they are aware of the alternatives [112]. The implementation of a readmission reduction program would cause significant financial penalties for hospitals that do not meet the requirements, and policy makers are considering an expansion and modification of the readmission reduction program [133]. The health care industry is facing increasingly complex challenges, such as new regulatory requirements.

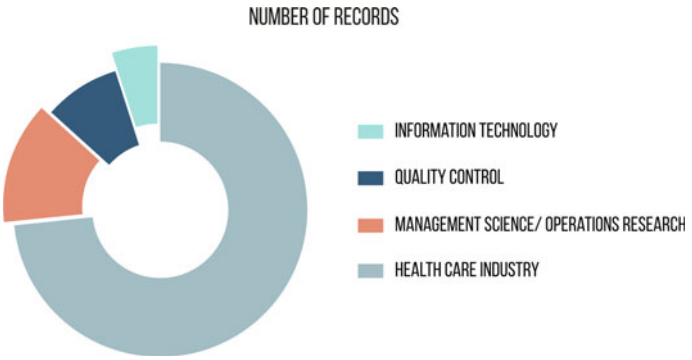


Fig. 3.15 Classifications of EDs studies by themes/subjects after study

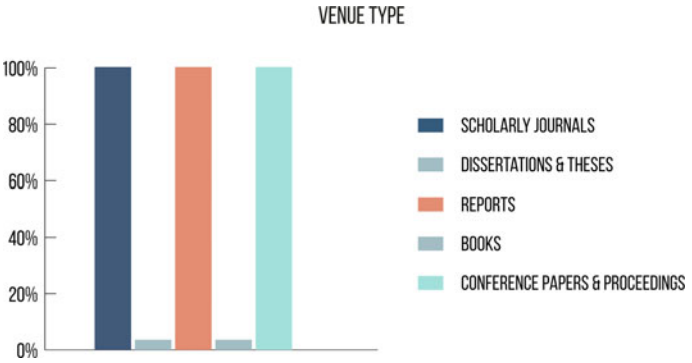
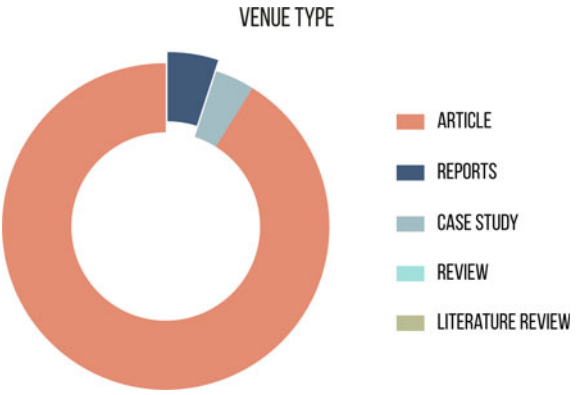


Fig. 3.16 Classifications of EDs studies by source before study

Fig. 3.17 Classifications of EDs studies by source after study



3.5.1.2 Medical Data

The clinical information about patients in a facility is vital to increase the quality of healthcare services, especially in the EDs of hospitals [41]. The major issue that was helpful in the data collection, storage, analysis and near real-time availability of the ED was an improvement in the methods for recording data in health care facilities where technology was lacking [44]. It is necessary to pay more attention to the problem of an administration's effectiveness [89].

3.5.1.3 Service Improvement

The quality of an ambulance service is related to the wait time as determined by the possibility of all ambulances being busy [9]. It is necessary to address reducing the patient wait times and enhancing the overall system throughput and service delivery at this stage [12]. Bed capacity at hospitals in the U.S. is at a premium and improving of service capacity is more feasible than increasing the physical capacity to respond to increasing patient volumes [30]. The issue of controlling costs under new reforms still has not yet been studied in detail [41]. Problem of measuring the throughput of services is traditionally considered to be a complicated issue [81].

3.5.1.4 Overcrowding

Overcrowding is a challenge for hospitals and requires strategic tools [26]. A contributing factor to the challenge of overcrowding and increased wait times in the ED is created [27]. Overcrowding in some hospitals and longer wait times for minor and major issues has increased by 32% from 1999–2009 [51], with unnecessary visits being one factor [57]. A substantial part of Medicare beneficiaries could have reduced the overcrowding of emergency departments [58]. Overcrowding, particularly in the late afternoon, is made worse by the ED's lack of ability to move patients who need to be admitted due to lack of inpatient beds [125]. Emergency department operations are becoming outdated due to overcrowding, and new communication methods should be used to advance the system [144]. Overcrowding in EDs affects the quality of care [145], and therefore, resolving the issue of overcrowding in the emergency department and the imbalance between the need for emergency care and the available resources requires an evaluation of the triage process [148].

3.5.1.5 Management

The Saudi national guidelines provide a comparison of the recorded management of acute bronchial asthma in the ER [4] for example. The UK is searching for a way to improve operation processes in hospitals, and there is substantial pressure to provide processes to improve the system that will be cost effective [6]. Spanish hospitals

concentrate on shift management [16]. Simulations create a decision support system for EDs that help the heads of EDs establish management guidelines that improve their operations [49]. It is of critical importance to find a way to develop mechanisms of management that would simultaneously focus on effectiveness and efficiency, with more attention being paid to the problem of the administration's effectiveness [89]. It has been proven that patient engagement in decision-making, self-management and prevention activities improves health outcomes [95]. Effective management of health care in the U.S. is critically dependent on effective management [141].

3.5.1.6 High Number of Visits

In the U.S., at the hospital-level, the ED performance on visit length and wait time are major issues [24]. The number of visits to the ED increased by 32% from 1999–2009. Some of these increases in ED visits led to ED overcrowding and longer wait times [51]. Many frequent emergency department users do not have any serious diseases except for mental illness; however, they contribute to ED overcrowding by making unnecessary visits [57]. The New Mexico Health Information Collaborative is a newly invented e-porting project, which will collect a wider array of information about all ED visits in a timely manner in an effort to make changes in authority, mechanisms, design, and approach [102]. Over the past two decades, the number of visits to EDs has increased. However, ED visits for some conditions have decreased while others have demonstrated varying patterns [127], and this presents barriers to assessing primary care [131]. Furthermore, patients return to the ED for more, visits and, hence, there is need to solve this problem [147].

3.5.1.7 Waiting Time

The risk and suffering this are faced by patients while waiting in line needs to be modeled, and changes in the patient's condition while the patient waits need to be considered [5]. Ambulance services have drawn substantial attention in operations research, and a vital aspect of the ambulance service is the wait time [9]. A reduction of patient wait times can enhance the overall system throughput and service delivery [12]. Numerous effects on ED wait time, boarding, and treatment times have been shown across multiple acuity groups and sites [19]. The growing public demand for ED services contributes the challenge of increased wait times in the ED [27]. The ED is considered the front door of the hospital and wait times and inpatient experiences create the perceptions of patients regarding the ED [126].

3.5.1.8 Collective Skills

Expressing collective skills as a mathematical model that can allow emulation of the behavior of the facilities and workforce and its components, shape the optimization

when a problem is faced and satisfy various requirements is required [25]. There is an effort regarding the effectiveness of teaching emergency medicine in terms of skills, knowledge, and attitudes outside the clinical environment [45]. Numerous reports show that emergency departments in the U.S. experience problems concerning behavioral disorders [56]. There is a shortage of studies that evaluate the influence of behavior [67]. A powerful driver of significant improvements in the field of health outcomes is the improvement of behavioral health conditions [106]. One of the most well-known mechanisms of achieving a reliable environment in which all workers look for, and report, small problems or unsafe conditions before those issues pose a substantial risk to the organization is seeking zero defects in outcomes quality and achieving high reliability [140], which are resilience skills [151].

3.5.2 Emergency System Tools

The tools used to research trends in the past decades in healthcare emergency system operations are primary and secondary data in the form of empirical, national, observation, case study and simulation research. Primary data are data that are collected (data that are collected by a researcher from first-hand sources) through observations [6], surveys [146], or other sources. Although most studies did not specifically mention that their source of data was primary, it could be inferred from the research tool used such as those listed in the research tools in the previous paragraph except for the literature reviews. In contrast, some studies used secondary data (data gathered from studies, surveys, or experiments that have been examined by other people or for other research) which include reviewing what other researchers have published about the same issue [9, 14], collecting data from a specific database [43], gathering information about patients who visited the emergency department from health record reviews [148], and collecting data from papers selected using a specific criteria [153].

3.5.3 Emergency System Approaches

The approaches used to track the trends in the past decades in healthcare emergency system operations are interviews, surveys, reviews of literature, and analyses carried out using meta-analysis, correlation, linear/nonlinear regression, logistic/multinomial regression, and mean differences.

In addition to empirical data [35, 38, 62], meta-analysis was used as a methodology for various aims including the calculation of adjusted medical costs [33], determination of the process needed for transformation of the U.S. emergency care system [59], description of the regionalized trauma system, determination of the effectiveness of and provision of recommendations regarding the further development of the emergency health care system [60], or other purposes [93, 94, 97].

Computer simulation is one of the most widely used methods of evaluating, improving, and optimizing many types of processes because it is an imitation of an actual process over time [2]. System simulation is used in estimation of the target function and optimization to calculate and authenticate the optimal configuration of servers [3]. In addition, the simulation model is employed to test various process scenarios, assign resources, and complete activity-based cost analysis [7]. Simulation is also integrated with optimization to establish the optimal number of nurses, lab technicians, and doctors needed to reduce patient time in the system and maximize patient throughput [23].

The simulation model is used to study ED operations [125]. Some studies also simulate an existing ED system after collecting actual data from the system [154]. Finally, the case study methodology was rarely used with a Chilean ambulance firm [9] and with the EDs of two university hospitals in the United States and Brazil [151]. In most cases, various types of regression were used in analyzing the data. Linear regression was mainly used to assess goodness-of-fit [1], to predict a specific outcome [31, 57] [77], to estimate a specific outcome [100], and to assess the influence of a specific factor on the outcome, the influence of an insurer-initiated price transparency program on costs per unit [112], and the influence of comments on patients' intention to recommend the specific hospital and their rating [118].

Moreover, a nonlinear regression model was rarely used [26]. Logistic regression [32, 34, 132] was used when the outcome variable was dichotomous, and multinomial regression [152] was used when the outcome variable was polytomous. A correlational analysis was used to assess the relationship between the variation in admission rates and national health expenditures [109], among the main cost variables of health care services [111], external consultants, system managers and the hospital team [114], between time and cost [129], and between community health centers and the Medicaid program using patient and insurance data [130]. The mean differences using t-tests [73] or other statistical tests [34, 112, 152] were also used in analyzing ED data. The type of factors included wait time, cost, registration process, number of visits and other medicals processes.

3.5.4 Emergency System KPIs

The emergency system KPI trends of the past decades in healthcare emergency system operations are health care quality, medical cost, services' processing time, satisfaction, length of stay, efficiency of ED services, access of heath care, performance, admission, and demographic characteristics.

3.5.4.1 Emergency System Quality

Health care quality was a main theme that researchers intended to measure. Health care quality was operationalized in terms of various variables such as quality and

the type of processes and outputs involved in the health care system [8, 55], quality of the processes of service [18, 28], quality of care [33, 36, 41, 65, 77, 84, 85, 95, 108], clinical quality [34, 89], quality of teamwork [36], changes in health care quality [38], quality of medical services [61], quality of care delivery [88], medication administration quality [89], quality of behavioral health care [106], quality of plans [136], and service quality [139].

3.5.4.2 Emergency Medical Service Cost

The many issues related to cost were the main concern in ED research and included minimum cost configuration of servers that satisfy the user [3], overall medical costs [33, 35, 63, 111, 129], health care costs [98, 106, 107, 109, 139, 140], medical and pharmacy costs [34], cost savings [37, 52, 58], costs of care [41, 54, 69, 84], acute injury costs [69], ED costs [76], cost per beneficiary [88], out-of-pocket costs for health services [97], treatment costs [108], patient costs [100], benefit costs [111], cost per discharged patient [129], healthcare cost and utilization [133], cost of overtime [149], cost of increasing one-unit capacity in hospital [149], and cost of income of accepted patients [149].

3.5.4.3 Emergency Services Processing Time

Researchers were also concerned with measuring the time of medical service delivery including process time [7], time of initial registration at the ED, time until placed into an ED treatment bed, time of hospital bed request, time of discharge from the ED facility [15], cycle time [17], treatment and boarding time [19, 20], wait time [24, 27, 44, 51, 117, 126, 144], time to transfer a patient to a medical facility [116], time of assessment by nurse, time of assessment by doctor, consultation time, time of arrival to a specific area, time of arrival to a consulted specialty, time of laboratory investigation, time of radiological investigation, time of final disposition and time of physical disposition [120], doctor-patient contact time, delay time for lab results and doctor-patient contact, interarrival time and time spent at registration counter [122], processing time [145], time of triage [148], and cost of overtime [149].

3.5.4.4 Emergency Patients Output Feedback

Patient output feedback includes a patient's satisfaction [54, 77, 107, 108, 113, 115], the staff's satisfaction of hard and soft constraints imposed by the monthly schedule [16], and the staff's satisfaction in general [76, 107].

3.5.4.5 Emergency Patients Length of Stay

Researchers were also concerned with the length of stay and queuing times for patients with both minor and major illnesses [6], length of patient stay in the ED [49, 52, 78, 114, 145, 148], length of queues [154], and visit length [24].

3.5.4.6 Emergency Services Efficiency

Measuring the efficiency of ED services provided to patients was an issue for some studies and included the effect of staffing levels on service efficiency [23], the efficiency of heath care services [113], the efficiency that reduces health care costs [139], and the ED efficiency [144].

3.5.4.7 Emergency Access of Services

A few studies aimed to measure a critical variable, such as accessibility of ED health care, which included access to behavioral health care [106, 116], access blocks [114] or barriers [115], and geographic access [136].

3.5.4.8 Emergency Services Performance

Some studies developed measures or indicators of performance in ED service including "output" performance measures such as daily work hours, personnel shifts, and lunch breaks [2], performance monitoring [10], physicians' performance on care quality [41], overall hospital performance [62], and indicators of work performance [142] such as the mean busy period [150].

3.5.4.9 Emergency Admission

Another important issue that attracted the attention of some studies was hospital admission. The studies in ED research were interested in measuring the impact of delayed admission [6], hospital admission [107] and readmission rates [34, 133, 140] and the probability of subsequent inpatient admission [52], ED admission rate [102, 119, 124, 125] and risk-standardized admission rates [109].

3.5.4.10 Demographic Characteristics

Demographic characteristics were also measured in order to test their relationship with factors involved in ED research including demographic characteristics of frequent ED users [11, 57, 127], demographic traits and ages of people who died

from unintentional drowning [123], relationship between demographic characteristics and occupancy ratio, emergency department occupancy, length of stay, time of triage [148], and relation between demographic characteristics and specific vulnerability conditions, such as drug and alcohol abuse, psychological distress and chronic conditions [152].

3.5.5 Emergency System Expected Results

The results of the trends of the past decades in healthcare emergency system operations include quality care, process simulation, well decisions, savings, improved services, and better experience.

3.5.5.1 Quality Care

The use of new technology would improve quality management with regards to processes and would be improved by enhancing staff ownership [8]. A collaborative accountable care initiative may improve the quality of care and decrease medical costs [33]. Teamwork in hospitals and health organizations would be an effective and efficient instrument to improve [36] the time for problem solving [38]. New payment incentives might be useful for ensuring better performance [41]. Integrated networks of emergency care have a potential to significantly increase the level of patient satisfaction and to improve the quality of services [55]. Quality of service and readiness for disasters do not meet the U.S. national requirements [59]. Modeling has a potential to improve service quality and reduce costs [76]. Customized information technology is a promising instrument to improve the quality and costs of care for seniors with multiple conditions [84]. The staff's insufficient knowledge and lack of understanding, along with low-quality training, were the main reasons blocking improvement [99]. Defining standards to promote quality improvement and identifying and removing any existing elements of quality measures that tend to increase the likelihood of patient behavior change could be helpful [132].

3.5.5.2 Process Simulation

Simulation modeling can allow several alternatives to be considered before any resources, especially human, are expended, and a simulation model imitates a system's behavior, which is referred to as "baselining." Simulation modeling evaluates possible changes in the system's structure, environment, or underlying assumptions in the form of a "what-if analysis" [2]. It is clear that a simulation model is a very effective method for identifying solutions to resource levels [10]. A simulation of different scenarios of ED patient flow led to the acknowledgment that ED diversion could result in discharge of patient one hour earlier [17]. The optimization simulation

model yields optimal staffing allocation that would facilitate an average reduction of 40% of patient wait time and a 28% increase in patient throughput [27]. Simulation tools have not been widely implemented [99]. Dynamic behavior in the ED can be acceptably modeled through simulation [125]. A greater use of the processes positively influences patient experience and the quality of health care [141].

3.5.5.3 Optimal Decisions

Real time information can also be used to determine where to build a health care facility and to determine the density of these facilities in each area [43]. Good decisions can reduce expenses by millions of dollars annually [58]. There is universal pattern that would explain the connection between a decision and the analysis of the unique features of each situation in healthcare [65]. It is crucial to develop field triangle guidelines that would prevent EDs from transporting low risk injured patients, and this decision could save millions of dollars annually in the U.S. healthcare system [69]. Other factors influence decisions, such as delays in payments [80], shared decision-making tends to reduce medical costs [98]. A logical decision in the U.S. health care system was developed, and a model demonstrated its extreme effectiveness in ensuring a higher quality of care, in lowering treatment costs and creating a higher level of patient satisfaction [108].

3.5.5.4 Savings

Hospital observation units are very promising when considering how to reduce costs; in all U.S. hospitals the unit has generated $1572 cost savings per patient [37]. The expected savings in Medicare is approximately $283–$560 million annually in the U.S. healthcare system if the guidelines are followed. It has been proven that the decision to prevent EDs from transporting low risk injured patients saves approximately $136.7 million annually in the U.S. healthcare system [69]. Mobile clinics have the potential to lead to significant cost savings [101].

3.5.5.5 Improved Processes

Healthcare is a dynamic service industry with high human involvement [2]. Shorter wait times increase the service level [12]. An increase in the level of patient satisfaction improves the quality of services [55]. Quality assurance has been proven to have the most effective potential to improve service quality and reduce costs [76].

3.5.5.6 Better Experience

The more experienced and the greater number of ED staff, the less the mean length of stay for a patient is [49]. The positive experience of Japan may be useful for the U.S. health response system [53]. A strong commitment to the community implies a high level of patient experience of care [77]. Patient outcomes can be improved by telephone-based coaching services [86]. Patient engagement has a positive impact on both health outcomes and care experiences [94]. There are important relationships that exist between a favorable ED experience and a favorable inpatient experience [126]. The patient experience is positively influenced by greater use of the process analysis [141].

3.5.6 Emergency System Deficiency and Shortcoming

The deficiency and shortcomings of the trends of the past decades in healthcare emergency system operations are data availability, errors, traffic conclusions and cost.

3.5.6.1 Data Availability

The data set did not have a chief diagnosis or complaint, which made it difficult to adequately assess the reasons for patient visits. Nevertheless, it is also impossible to generalize the data from one hospital to other hospitals [11]. The data were collected over the summer which made it difficult to generalize the data to other seasons [12]. The database limited the ability of the researchers to extrapolate national estimates about the subgroups of interest that are reliable [13]. A substantial amount of data was required in order to make a good estimate of the input values [20]. The data were self-reported by patients, [31] and the risk of multiple biases was significant [34]. The searching tools that were used in the business and engineering databases were not as detailed [48]. The data sets do not exclusively contain information about hospitals [71], and there was a limited amount of data available [125].

3.5.6.2 Errors

The inaccurate data that were due to estimation may lead to inaccurate results and, therefore, errors [21]. Software limitations led to problems in weighting the medial wait time results [22]. The databases were not as detailed [48], and there was a risk of transforming the databases' errors and other scholars' biases into the eventual conclusions [54]. There were many errors and limitations from other sources [55]. There was a potential inconsistency between the data sets [71]. Many agencies may

have misreported some of their quality parameters [111]. A single source of data may contain errors [117].

3.5.6.3 Desistance

The conclusions require confirmation, [35] but the conclusions regarding the extreme effectiveness should be verified [52]. Emergency departments can improve their services, but studies that support the conclusions about behavioral disorders and other parameters are required [56].

3.5.6.4 Cost

The costing method was employed for calculating savings [37]. There was a potential correlation between the variation in cost and the quality of physicians' performance that provided higher-quality care [41]. It is necessary to conduct a cost-effectiveness analysis [69], as there are some errors in many of the cost reports [111].

3.6 Conclusion

In conclusion, the issues faced by EDs can be resolved if the cost of quality is controlled and managed effectively, and patient data are recorded appropriately. Moreover, the managers in EDs are expected to prevent overcrowding and prolonged wait times by managing the patient visits and exploiting the skills and expertise of the staff. The managers must obtain primary and secondary data through interviews, surveys, and literature reviews and by conducting research at the clinical and national levels. The managers must interpret and process the data through meta-analysis and must be capable of noting similarities, disparities and weaknesses of the wait time, process of patient registration, costs, patient visits, and other aspects.

The ED manager is expected to conduct interviews, assessments, literature reviews and meta-analysis, and determine the correlation, various types of regression and average differences in order to investigate aspects such as wait times, the process of patient registration, costs, number of visits and others. The ED manager must pay attention to the standard of healthcare services, cost of treatment, time consumed by services, patient satisfaction, length of stay, quality of performance of the ED, access to health care, patient admission, and demographics. The effectiveness of healthcare services can be ensured if the manager prevents assumptions, biased conclusions, single step data collection, employment of meta-analysis for primary data-analysis, data collection from particular sources of data, employing a costly system and data recording errors as in case of self-reporting patients.

3.7 Future Work

The expertise and skills of the personnel involved in healthcare provision can be explored by conducting multilabel studies [2]. Emergency departments need a management [3] that provides leadership [2] to the employees that facilitates smooth operations in EDs. The management of the ED must ensure that the quality of the care and services is improved and revised with time [3]. Research regarding the performance appraisal of emergency systems and that ensures that the practice of obtaining real-time patient data in EDs is continued is necessary. Future studies must evaluate the performance of emergency departments in the context of a the demographic features of patients, the shift of a patient through the ambulance, the time acquired by the ED to provide for patient needs and evaluation of EDs processing time by simulation.

References

1. Almozayen, N.A., Othman, M.K.B., Gani, A.B., Alharethi, S.Z.: Data mining techniques: a systematic mapping review. In: Saeed, F., Gazem, N., Patnaik, S., Saed Balaid, A., Mohammed, F. (eds.) Recent Trends in Information and Communication Technology. IRICT 2017. Lecture Notes on Data Engineering and Communications Technologies, vol 5. Springer, Cham (2018)
2. Alharethi, S., Gani, A., Othman, M.K.: Emergency departments. In: Arai, K., Kapoor, S., Bhatia, R. (eds.) Advances in Information and Communication Networks. FICC 2018. Advances in Intelligent Systems and Computing, vol 887. Springer, Cham (2019)
3. Zayed, S.B., Gani, A.B., Othman, M.K.: System Reengineering in Healthcare: Application for Hospital Emergency Departments. Springer, Berlin (2018)
4. Hagquist, C., Stenbeck, M.: Goodness of fit in regression analysis—R 2 and G 2 reconsidered. Qual. Quant. **32**(3), 229–245 (1998)
5. Merkle, J.F.: Computer simulation: a methodology to improve the efficiency in the Brooke Army Medical Center family care clinic. J. Healthc. Manage. **47**(1), 58 (2002)
6. De Angelis, V., Felici, G., Impelluso, P.: Integrating simulation and optimisation in health care centre management. Eur. J. Oper. Res. **150**(1), 101–114 (2003)
7. Al-Jahdali, H.H., Al-Omar, A.M., Al-Moamary, M.S., Al-Duhaim, A.S., Al-Hodeib, A.S., Hassan, I.S., Al-Rabegi, A.M.: Implementation of the national asthma management guidelines in the emergency. Saudi Med. J. **25**(9), 1208–1211 (2004)
8. Wang, Q.: Modeling and analysis of high risk patient queues. Eur. J. Oper. Res. **155**(2), 502–515 (2004)
9. Komashie, A., Mousavi, A.: Modeling emergency departments using discrete event simulation techniques. In: Proceedings of the Winter Simulation Conference, 4 Dec 2005, 5 p. IEEE (2005)
10. Ruohonen, T., Neittaanmaki, P., Teittinen, J.: Simulation model for improving the operation of the emergency department of special health care. In: Proceedings of the 2006 Winter Simulation Conference, 3 Dec 2006, pp. 453–458. IEEE (2006)
11. Komashie, A., Mousavi, A., Gore, J.: Quality management in healthcare and industry: a comparative review and emerging themes. J. Manage. Hist. **13**(4), 359–370 (2007)
12. Singer, M., Donoso, P.: Internal supply chain management in the Chilean sawmill industry. Int. J. Oper. Prod. Manage. **27**(5), 524–541 (2007)

13. Oddoye, J.P., Yaghoobi, M.A., Tamiz, M., Jones, D.F., Schmidt, P.: A multi-objective model to determine efficient resource levels in a medical assessment unit. J. Oper. Res. Soc. **58**(12), 1563–1573 (2007)
14. Rehmani, R., Norain, A.: Trends in emergency department utilization in a hospital in the Eastern region of Saudi Arabia. Saudi Med. J. **28**(2), 236 (2007)
15. Duguay, C., Chetouane, F.: Modeling and improving emergency department systems using discrete event simulation. Simulation **83**(4), 311–320 (2007)
16. Baumgartner, E.A., Belson, M., Rubin, C., Patel, M.: Hypothermia and other cold-related morbidity emergency department visits: United States, 1995–2004. Wilderness Environ. Med. **19**(4), 233–237 (2008)
17. Moskop, J.C., Sklar, D.P., Geiderman, J.M., Schears, R.M., Bookman, K.J.: Emergency department crowding, part 1—concept, causes, and moral consequences. Ann. Emerg. Med. **53**(5), 605–611 (2009)
18. Hoot, N.R., LeBlanc, L.J., Jones, I., Levin, S.R., Zhou, C., Gadd, C.S., Aronsky, D.: Forecasting emergency department crowding: a discrete event simulation. Ann. Emerg. Med. **52**(2), 116–125 (2008)
19. Puente, J., Gómez, A., Fernández, I., Priore, P.: Medical doctor rostering problem in a hospital emergency department by means of genetic algorithms. Comput. Ind. Eng. **56**(4), 1232–1242 (2009)
20. Kolker, A.: Process modeling of emergency department patient flow: effect of patient length of stay on ED diversion. J. Med. Syst. **32**(5), 389–401 (2008)
21. Hoot, N.R., Aronsky, D.: Systematic review of emergency department crowding: causes, effects, and solutions. Ann. Emerg. Med. **52**(2), 126–136 (2008)
22. McCarthy, M.L., Zeger, S.L., Ding, R., Levin, S.R., Desmond, J.S., Lee, J., Aronsky, D.: Crowding delays treatment and lengthens emergency department length of stay, even among high-acuity patients. Ann. Emerg. Med. **54**(4), 492–503 (2009)
23. Al-Kattan, I., Abboud, B.: Disaster recovery plan development for the emergency department—case study. Public Adm. Manage. **14**(1) (2009)
24. Darabi, H., Galanter, W.L., Lin, J.Y., Buy, U., Sampath, R.: Modeling and integration of hospital information systems with Petri nets. In: 2009 IEEE/INFORMS International Conference on Service Operations, Logistics and Informatics, 22 July 2009, pp. 190–195. IEEE (2009)
25. Horwitz, L.I., Bradley, E.H.: Percentage of US emergency department patients seen within the recommended triage time: 1997 to 2006. Arch. Intern. Med. **169**(20), 1857–1865 (2009)
26. Ahmed, M.A., Alkhamis, T.M.: Simulation optimization for an emergency department healthcare unit in Kuwait. Eur. J. Oper. Res. **198**, 936–942 (2009)
27. Horwitz, L.I., Green, J., Bradley, E.H.: US emergency department performance on wait time and length of visit. Ann. Emerg. Med. **55**(2), 133–141 (2010)
28. Skruch, P., Mitkowski, W.: Modelling and simulation of the shape optimization problems. Model. Simul. Optim. **1**, 187–208 (2010)
29. Cochran, J.K., Broyles, J.R.: Developing nonlinear queuing regressions to increase emergency department patient safety: approximating reneging with balking. Comput. Ind. Eng. **59**(3), 378–386 (2010)
30. Rutherford, K.H.: Efficacy of emergency department fast tracks in relieving overcrowding. Doctoral dissertation, University of Phoenix.
31. Güneş, E.D., Yaman, H.: Health network mergers and hospital re-planning. J. Oper. Res. Soc. **61**(2), 275–283 (2010)
32. Al-Omar, B., Al-Ghanim, S.: Utilization of hospital resources: a survey-based study of Saudi hospitals in Riyadh City. Clin. Gov. Int. J. **15**(2), 134–141 (2010)
33. Drazen, E.: Using tracking tools to improve patient flow in hospitals [online] (April 2011)
34. Malyon, R., Zhao, Y., Oates, B.: Differences in the cost of admitted patient care for Indigenous people and people from remote locations. Aust. Health Rev. **37**(1), 26–31 (2013)
35. Shin, D.Y., Menachemi, N., Diana, M., Kazley, A.S., Ford, E.W., Allen, R.L.: Payer mix and EHR adoption in hospitals/practitioner application. J. Healthc. Manage. **57**(6), 435–448; discussion 449–450 (2012)

36. Salmon, R.B., Sanderson, M.I., Walters, B.A., Kennedy, K., Flores, R.C., Muney, A.M.: innovation profile: a collaborative accountable care model in three practices showed promising early results on costs and quality of care. Health Aff. **31**(11), 2379–2387 (2012)
37. Rosenberg, C.N., Peele, P., Keyser, D., McAnallen, S., Holder, D.: Results from a patient-centered medical home pilot at UPMC health plan hold lessons for broader adoption of the model. Health Aff. **31**(11), 2423–2431 (2012)
38. Takach, M.: About half of the states are implementing patient-centered medical homes for their medicaid populations. Health Aff. **31**(11), 2432–2440 (2012)
39. Chesluk, B.J., Bernabeo, E., Hess, B., Lynn, L.A., Reddy, S., Holmboe, E.S.: Innovation profile: a new tool to give hospitalists feedback to improve interprofessional teamwork and advance patient care. Health Aff. **31**(11), 2485–2492 (2012)
40. Baugh, C.W., Venkatesh, A.K., Hilton, J.A., Samuel, P.A., Schuur, J.D., Bohan, J.S.: Making greater use of dedicated hospital observation units for many short-stay patients could save $3.1 billion a year. Health Aff. **31**(10), 2314–2323 (2012)
41. Esain, A.E., Williams, S.J., Gakhal, S., Caley, L., Cooke, M.W.: Healthcare quality improvement—policy implications and practicalities. Int. J. Health Care Qual. Assur. **25**(7), 565–581 (2012)
42. Weissman, J.S., Bailit, M., D'Andrea, G., Rosenthal, M.B.: The design and application of shared savings programs: lessons from early adopters. Health Aff. **31**(9), 1959–1968 (2012)
43. Mehrotra, A., Lave, J.R.: Visits to retail clinics grew fourfold from 2007 to 2009, although their share of overall outpatient visits remains low. Health Aff. **31**(9), 2123–2129 (2012)
44. Ellis, P., Sandy, L.G., Larson, A.J., Stevens, S.L.: Wide variation in episode costs within a commercially insured population highlights potential to improve the efficiency of care. Health Aff. **31**(9), 2084–2093 (2012)
45. Jiang, L., Xu, B., Fang, L., Cai, H.: A ubiquitous clinic data accessing method based on resource model. In: 2012 IEEE ninth international conference on e-business engineering, 9 Sept 2012, pp 221–226. IEEE (2012)
46. Murad, A.A.: Benchmarking the location of health centers at Jeddah city: a GIS approach. Benchmarking Int. J. **19**(1), 93–108 (2012)
47. Stone-Griffith, S., Englebright, J.D., Cheung, D., Korwek, K.M., Perlin, J.B.: Data-driven process and operational improvement in the emergency department: the ED dashboard and reporting application. J. Healthc. Manage. **57**(3), 167–181 (2012)
48. Deiorio, N.M., Fitch, M.T., Jung, J., Promes, S.B., Thibodeau, L.G., Woolley, W.L., Gisondi, M.A., Gruppen, L.D.: Evaluating educational interventions in emergency medicine. Acad. Emerg. Med. **19**(12), 1442–1453 (2012)
49. Khan, T.M., Shahzad, C.M., Ahmed, M.K., Azhar, S.: Attitudes of emergency department staff towards the role of clinical pharmacists in a region of Saudi Arabia—a pilot study. Trop. J. Pharm. Res. **11**(3), 477–483 (2012)
50. Weiss, J.C., Natarajan, S., Peissig, P.L., McCarty, C.A., Page, D.: Machine learning for personalized medicine: predicting primary myocardial infarction from electronic health records. AI Mag. **33**(4), 33 (2012)
51. Lim, M.E., Nye, T., Bowen, J.M., Hurley, J., Goeree, R., Tarride, J.E.: Mathematical modeling: the case of emergency department waiting times. Int. J. Technol. Assess. Health Care **28**(2), 93–109 (2012)
52. Cabrera, E., Taboada, M., Iglesias, M.L., Epelde, F., Luque, E.: Simulation optimization for healthcare emergency departments. Procedia Comput. Sci. **1**(9), 1464–1473 (2012)
53. Alharthi, S.Z.: Towards a sustainable competitive advantage. Int. J. Bus. Res. Dev. **1**(1) (2012)
54. Bhuiya, F.A., Hing, E.: Wait time for treatment in hospital emergency departments (2009)
55. Ross, M.A., Hockenberry, J.M., Mutter, R., Barrett, M., Wheatley, M., Pitts, S.R.: Protocol-driven emergency department observation units offer savings, shorter stays, and reduced admissions. Health Aff. **32**(12), 2149–2156 (2013)
56. Parmar, P., Arii, M., Kayden, S.: Learning from Japan: strengthening US emergency care and disaster response. Health Aff. **32**(12), 2172–2178 (2013)

57. Hwang, U., Shah, M.N., Han, J.H., Carpenter, C.R., Siu, A.L., Adams, J.G.: Transforming emergency care for older adults. Health Aff. **32**(12), 2116–21121 (2013)
58. Martinez, R., Carr, B.: Creating integrated networks of emergency care: from vision to value. Health Aff. **32**(12), 2082–2090 (2013)
59. Bernstein, S.L., D'Onofrio, G.: A promising approach for emergency departments to care for patients with substance use and behavioral disorders. Health Aff. **32**(12), 2122–2128 (2013)
60. Billings, J., Raven, M.C.: Dispelling an urban legend: frequent emergency department users have substantial burden of disease. Health Aff. **32**(12), 2099–2108 (2013)
61. Alpert, A., Morganti, K.G., Margolis, G.S., Wasserman, J., Kellermann, A.L.: Giving EMS flexibility in transporting low-acuity patients could generate substantial medicare savings. Health Aff. **32**(12), 2142–2148 (2013)
62. Lurie, N., Margolis, G.S., Rising, K.L.: The US emergency care system: meeting everyday acute care needs while being ready for disasters. Health Aff. **32**(12), 2166–2171 (2013)
63. Eastman, A.B., MacKenzie, E.J., Nathens, A.B.: Sustaining a coordinated, regional approach to trauma and emergency care is critical to patient health care needs. Health Aff. **32**(12), 2091–2098 (2013)
64. Rosenbaum, S.: The enduring role of the emergency medical treatment and active labor act. Health Aff. **32**(12), 2075–2081 (2013)
65. Jeremy Henri, M.V., Schiøtz, M.L., Guisset, A.-L., Adalsteinn, D.B., Klazinga, N.S.: The PATH project in eight European countries: an evaluation. Int. J. Health Care Qual. Assur. **26**(8), 703–713
66. Enard, K.R., Ganelin, D.M., Dent, R.L.: Reducing preventable emergency department utilization and costs by using community health workers as patient navigators. J. Healthc. Manage. **58**(6), 412–427; discussion 428 (2013)
67. Elwood, T.W.: Analysis & commentary: patchwork of scope-of-practice regulations prevent allied health professionals from fully participating in patient care. Health Aff. **32**(11), 1985–1989 (2013)
68. Everett, C., Thorpe, C., Palta, M., Carayon, P., Bartels, C., Smith, M.A.: Physician assistants and nurse practitioners perform effective roles on teams caring for medicare patients with diabetes. Health Aff. **32**(11), 1942–1948 (2013)
69. Dower, C., Moore, J., Langelier, M.: Analysis & commentary: it is time to restructure health professions scope-of-practice regulations to remove barriers to care. Health Aff. **32**(11), 1971–1976 (2013)
70. Torchiana, D.F., Colton, D.G., Rao, S.K., Lenz, S.K., Meyer, G.S., Ferris, T.G.: Innovation profile: Massachusetts general physicians organization's quality incentive program produces encouraging results. Health Aff. **32**(10), 1748–1756 (2013)
71. Kirby, J.B., Kaneda, T.: 'Double Jeopardy' measure suggests blacks and hispanics face more severe disparities than previously indicated. Health Aff. **32**(10), 1766–1772 (2013)
72. Newgard, C.D., Staudenmayer, K., Hsia, R.Y., Mann, N.C., Bulger, E.M., Holmes, J.F., et al.: The cost of overtriage: more than one-third of low-risk injured patients were taken to major trauma centers. Health Aff. **32**(9), 1591–1599 (2013)
73. Miranda, M.L., Ferranti, J., Strauss, B., Neelon, B., Califf, R.M.: Geographic health information systems: a platform to support the 'triple aim'. Health Aff. **32**(9), 1608–1615 (2013)
74. DesRoches, C.M., Worzala, C., Bates, S.: Some hospitals are falling behind in meeting 'meaningful use' criteria and could be vulnerable to penalties in 2015. Health Aff. **32**(8), 1355–1360 (2013)
75. Adler-Milstein, J., Bates, D.W., Jha, A.K.: Operational health information exchanges show substantial growth, but long-term funding remains a concern. Health Aff. **32**(8), 1486–1492 (2013)
76. Wharam, J.F., Zhang, F., Landon, B.E., Soumerai, S.B., Ross-Degnan, D.: Low-socioeconomic-status enrollees in high-deductible plans reduced high-severity emergency care. Health Aff. **32**(8), 1398–1406 (2013)

77. Harrison G., Zeitz, K., Adams, R., Mackay, M.: Does hospital occupancy impact discharge rates? Aust. Health Rev. **37**(4), 1–9 (2013)
78. Dilwali, P.K.: From acute care to home care: the evolution of hospital responsibility and rationale for increased vertical integration. J. Healthc. Manage. **58**(4), 267–276 (2013)
79. Ewing, M.: The patient-centered medical home solution to the cost-quality conundrum. J. Healthc. Manage. **58**(4), 258–266 (2013)
80. Kang, R., Hasnain-Wynia, R., Hood, M.M.: Hospital commitment to community orientation and its association with quality of care and patient experience. J. Healthc. Manage. **58**(4), 277–288; discussion 288–289 (2013)
81. Pallin, D.J., Allen, M.B., Espinola, J.A., Camargo, C.A., Bohan, J.S.: Population aging and emergency departments: visits will not increase, lengths-of-stay and hospitalizations will. Health Aff. **32**(7), 1306–1312 (2013)
82. Kangovi, S., Barg, F.K., Carter, T., Long, J.A., Shannon, R., Grande, D.: Understanding why patients of low socioeconomic status prefer hospitals over ambulatory care. Health Aff. **32**(7), 1196–1203 (2013)
83. Decker, S.L.: Two-thirds of primary care physicians accepted new medicaid patients in 2011–12: a baseline to measure future acceptance rates. Health Aff. **32**(7), 1183–1187 (2013)
84. Sherman, H.D., Zhu, J.: Analyzing performance in service organizations. MIT Sloan Manage. Rev. **54**(4), 37–42 (2013)
85. Dill, M.J., Pankow, S., Erikson, C., Shipman, S.: Survey shows consumers open to a greater role for physician assistants and nurse practitioners. Health Aff. **32**(6), 1135–1142 (2013)
86. Melnick, G., Fonkych, K.: Fair pricing law prompts most california hospitals to adopt policies to protect uninsured patients from high charges. Health Aff. **32**(6), 1101–1108 (2013)
87. Tanio, C., Chen, C.: Innovations at miami practice show promise for treating high-risk medicare patients. Health Aff. **32**(6), 1078–1082 (2013)
88. Rosenberg, S.P., Hickie, I.B.: Making activity-based funding work for mental health. Aust. Health Rev. **37**(3), 277–280 (2013)
89. Dennis, S.M., Harris, M., Lloyd1, J., Davies, G.P., Faruqi, N., Zwar, N.: Do people with existing chronic conditions benefit from telephone coaching? A rapid review. Aust. Health Rev. **37**(3), 381–388 (2013)
90. Eibner, C., Goldman, D.P., Sullivan, J., Garber, A.M.: Three large-scale changes to the medicare program could curb its costs but also reduce enrollment. Health Aff. **32**(5), 891–899 (2013)
91. Davis, K., Schoen, C., Guterman, S.: Medicare essential: an option to promote better care and curb spending growth. Health Aff. **32**(5), 900–909 (2013)
92. Chircu, A.M., Gogan, J.L., Boss, S.R., Baxter, R.: Medication errors, handoff processes and information quality. Bus. Process Manage. J. **19**(2), 201–216 (2013)
93. Kozhimannil, K.B., Law, M.R., Virnig, B.A.: Cesarean delivery rates vary tenfold among US hospitals; reducing variation may address quality and cost issues. Health Aff. **32**(3), 527–535 (2013)
94. Kelley, A.S., Deb, P., Du, Q., Aldridge Carlson, M.D., Morrison, R.S.: Hospice enrollment saves money for Medicare and improves care quality across a number of different lengths-of-stay. Health Aff. **32**(3), 552–561 (2013)
95. Kutney-Lee, A., Sloane, D.M., Aiken, L.H.: An increase in the number of nurses with baccalaureate degrees is linked to lower rates of postsurgery mortality. Health Aff. **32**(3), 579–586 (2013)
96. Roseman, D., Osborne-Stafsnes, J., Amy, C.H., Boslaugh, S., Slate-Miller, K.: Early lessons from four 'aligning forces for quality' communities bolster the case for patient-centered care. Health Aff. **32**(2), 232–241 (2013)
97. Hibbard, J.H., Greene, J.: What the evidence shows about patient activation: better health outcomes and care experiences; fewer data on costs. Health Aff. **32**(2), 207–214 (2013)
98. Koh, H.K., Brach, C., Harris, L.M., Parchman, M.L.: A proposed 'health literate care model' would constitute a systems approach to improving patients' engagement in care. Health Aff. **32**(2), 357–367 (2013)

99. Han, E., Scholle, S.H., Morton, S., Bechtel, C., Kessler, R.: Survey shows that fewer than a third of patient-centered medical home practices engage patients in quality improvement. Health Aff. **32**(2), 368–375 (2013)
100. Corlette, S., Downs, D., Monahan, C.H., Yondorf, B.: State insurance exchanges face challenges in offering standardized choices alongside innovative value-based insurance. Health Aff. **32**(2), 418–426 (2013)
101. Veroff, D., Marr, A., Wennberg, D.E.: Enhanced support for shared decision making reduced costs of care for patients with preference-sensitive conditions. Health Aff. **32**(2), 285–293 (2013)
102. Brailsford, S.C., Bolt, T.B., Bucci, G., Chaussalet, T.M., Connell, N.A., Harper, P.R., et al.: Overcoming the barriers: a qualitative study of simulation adoption in the NHS. J. Oper. Res. Soc. **64**(2), 157–168 (2013)
103. Malyon, R., Zhao, Y., Oates, B.: Differences in the cost of admitted patient care for Indigenous people and people from remote locations. Aust. Health Rev. **37**(1), 26–31 (2013)
104. Song, Z., Hill, C., Bennet, J., Vavasis, A., Oriol, N.E.: Mobile clinic in Massachusetts associated with cost savings from lowering blood pressure and emergency department use. Health Aff. **32**(1), 36–44 (2013)
105. Ward, R., Gallagher, L., Landen, M.: 2013 Emergency Department Data Annual Report [Internet]. New Mexico Department of Health (2013)
106. Morganti, K.G., Bauhoff, S., Blanchard, J.C., Abir, M., Iyer, N., Smith, A., Vesely, J.V., Okeke, E.N., Kellermann, A.L.: The evolving role of emergency departments in the United States. RAND Health Q. **3**(2) (2013)
107. Courtney, M., Gopinath, B., Toward, M., Jain, R., Rao, M.: Are adequate fluid challenges prescribed for severe sepsis? Int. J. Health Care Qual. Assur. **27**(8), 719–728 (2014)
108. Edwards, S.T., Bitton, A., Hong, J., Landon, B.E.: Patient-centered medical home initiatives expanded in 2009–13: providers, patients, and payment incentives increased. Health Aff. **33**(10), 1823–1831 (2014)
109. Lewis, V.A., Colla, C.H., Tierney, K., Van Citters, A.D., Fisher, E.S., Meara, E.: Few ACOs pursue innovative models that integrate care for mental illness and substance abuse with primary care. Health Aff. **33**(10), 1808–1816 (2014)
110. Busse, R., Stahl, J.: Integrated care experiences and outcomes in Germany, The Netherlands, and England. Health Aff. **33**(9), 1549–1558 (2014)
111. Stock, S., Pitcavage, J.M., Simic, D., Altin, S., Graf, C., Feng, W., et al.: Chronic care model strategies in the united states and germany deliver patient-centered, high-quality diabetes care. Health Aff. **33**(9), 1540–1548 (2014)
112. Sabbatini, A.K., Nallamothu, B.K., Kocher, K.E.: Reducing variation in hospital admissions from the emergency department for low-mortality conditions may produce savings. Health Aff. **33**(9), 1655–1663 (2014)
113. Beaupert, F., Carney, T., Chiarella, M., Satchell, C., Walton, M., Bennett, B., et al.: Regulating healthcare complaints: a literature review. Int. J. Health Care Qual. Assur. **27**(6), 505–518 (2014)
114. Cabin, W., Himmelstein, D.U., Siman, M.L., Woolhandler, S.: For-profit medicare home health agencies' costs appear higher and quality appears lower compared to nonprofit agencies. Health Aff. **33**(8), 1460–1465 (2014)
115. Wu, S., Sylwestrzak, G., Shah, C., DeVries, A.: Price transparency for MRIs increased use of less costly providers and triggered provider competition. Health Aff. **33**(8), 1391–1398 (2014)
116. Walsh, T.P., Pilkington, D.C., Wong, E.J., Brown, C.H., Mercer, G.E.: Orthopaedic triaging by podiatrists: a prospective study of patient satisfaction and service efficiency. Aust. Health Rev. **38**(4), 406–411 (2014)
117. Bell, A., Cochrane, A., Courtice, S., Flanigan, K., Mathur, M., Wilckens, D.: Strength in unity: the power of redesign to align the hospital team. Aust. Health Rev. **38**(3), 271–277 (2014)
118. Allen, H., Wright, B.J., Baicker, K.: New Medicaid enrollees in Oregon report health care successes and challenges. Health Aff. **33**(2), 292–299 (2014)

119. Stingley, S., Schultz, H.: Helmsley trust support for telehealth improves access to care in rural and frontier areas. Health Aff. **33**(2), 336–341 (2014)
120. Green, J., Dawber, J., Masso, M., Eagar, K.: Emergency department waiting times: do the raw data tell the whole story? Aust. Health Rev. **38**(1), 1–5 (2014)
121. Huppertz, J.W., Smith, R., Bombard, C.F.: The value of patients' handwritten comments on HCAHPS surveys/practitioner application. J. Healthc. Manage. **59**(1), 31–47 (2014)
122. Ward, R., Gallagher, L., Landen, M.: Emergency Department Data Annual Report [Internet]. New Mexico Department of Health (2014)
123. Bukhari, H., Albazli, K., Almaslmani, S., Attiah, A., Bukhary, E., Najjar, F., Qari, A., Sulaimani, N., Al-Lihyani, A., Alhazmi, A., Al-Maghrabi, H.: Analysis of waiting time in emergency department of al-noor specialist hospital, Makkah, Saudi Arabia. Open J. Emerg. Med. **2**(04), 67 (2014)
124. Connelly, L.G., Bair, A.E.: Discrete event simulation of emergency department activity: a platform for system-level operations research. Acad. Emerg. Med. **11**(11), 1177–1185 (2004)
125. Ahmad, N., Ghani, N.A., Kamil, A.A., Tahar, R.M.: Emergency department problems: a call for hybrid simulation. In: Proceedings of the World Congress on Engineering, vol. 3, pp. 1–10 (2012)
126. Gilchrist, J., Parker, E.M.: Racial and ethnic disparities in fatal unintentional drowning among persons less than 30 years of age—United States, 1999–2010. J. Saf. Res. **1**(50), 139–142 (2014)
127. Weiss, A.J., Wier, L.M., Stocks, C., Blanchard, J:. Overview of emergency department visits in the United States, 2011. HCUP Statistical Brief. 174 (2014)
128. Carmen, R., Defraeye, M., Celik Aydin, B., Van Nieuwenhuyse, I.: Modeling emergency departments using discrete-event simulation: a real-life case study including patient boarding. FEB Research Report KBI_1420 (2014)
129. Davenport, P.J., O'Connor, S.J., Szychowski, J.M., Landry, A.Y., Hernandez, S.R.: The relationship between emergency department wait times and inpatient satisfaction. Health Mark. Q. **34**(2), 97–112 (2017)
130. Skinner, H.G., Blanchard, J., Elixhauser, A.: Trends in emergency department visits, 2006–2011: Statistical brief# 179
131. Sharpe, M.: Engaging front-line nurses to improve the outcomes of patient care, 2006–13. Health Aff. **34**(12), 2196–2201 (2015) [serial on the Internet] [cited August 16, 2017]. Available from: CINAHL Complete
132. Dyas, S., Greenfield, E., Messimer, S., Thotakura, S., Gholston, S., Hays, M., et al.: Process-improvement cost model for the emergency department. J. Healthc. Manage. **60**(6), 442–458 (2015) [serial on the Internet] [cited August 16, 2017]. Available from: Health Business Elite
133. Shin, P., Sharac, J., Rosenbaum, S.: Community health centers and Medicaid at 50: an enduring relationship essential for health system transformation. Health Aff. **34**(7), 1096–1104 (2015) [serial on the Internet] [cited August 16, 2017]. Available from: Health Business Elite
134. Wright, B., Potter, A., Trivedi, A.: Federally qualified health center use among dual eligibles: rates of hospitalizations and emergency department visits. Health Aff. **34**(7), 1147–1155 (2015) [serial on the Internet] [cited August 16, 2017]. Available from: Health Business Elite
135. Obermeyer, Z., Powers, B., Makar, M., Keating, N., Cutler, D.: Practice variation. Physician characteristics strongly predict patient enrollment in hospice. Health Aff. **34**(6): 993–1000 (2015) [serial on the Internet] [cited August 16, 2017]. Available from: Health Business Elite
136. Carey, K., Lin, M.: Readmissions to New York hospitals fell for three target conditions from 2008 to 2012, consistent with medicare goals. Health Aff. **34**(6), 978–985 (2015) (Project Hope) [serial on the Internet] [cited August 16, 2017]. Available from: MEDLINE Complete
137. Harding, P., Prescott, J., Sayer, J., Pearce, A.: Advanced musculoskeletal physiotherapy clinical education framework supporting an emerging new workforce*. Aust. Health Rev. **39**(3), 271–282 (2015) [serial on the Internet] [cited August 16, 2017]. Available from: CINAHL Complete
138. Skinner, E.H., Haines, K.J., Hayes, K., Seller, D., Toohey, J.C., Reeve, J.C., Holdsworth, C., Haines, T.P.: Future of specialised roles in allied health practice: who is responsible? Aust. Health Rev. **39**(3), 255–259 (2015)

139. Haeder, S.F., Weimer, D.L., Mukamel, D.B.: California hospital networks are narrower in Marketplace than in commercial plans, but access and quality are similar. Health Aff. **34**(5), 741–748 (2015)
140. Maeng, D.D., Khan, N., Tomcavage, J., Graf, T.R., Davis, D.E., Steele, G.D.: Reduced acute inpatient care was largest savings component of Geisinger Health System's patient-centered medical home. Health Aff. **34**(4), 636–644 (2015)
141. Hsia, R.Y., Nath, J.B., Baker, L.C.: California emergency department visit rates for medical conditions increased while visit rates for injuries fell, 2005–11. Health Aff. **34**(4), 621–626 (2015)
142. Rahurkar, S., Vest, J.R., Menachemi, N.: Despite the spread of health information exchange, there is little evidence of its impact on cost, use, and quality of care. Health Aff. **34**(3), 477–483 (2015)
143. Griffith, J.R.: Understanding high-reliability organizations: are baldrige recipients models? J. Healthc. Manage. **60**(1), 44–62 (2015)
144. Wiley, J.A., Rittenhouse, D.R., Shortell, S.M., Casalino, L.P., Ramsay, P.P., Bibi, S., Ryan, A.M., Copeland, K.R., Alexander, J.A.: Managing chronic illness: physician practices increased the use of care management and medical home processes. Health Aff. **34**(1), 78–86 (2015)
145. Gul, M., Guneri, A.F.: A comprehensive review of emergency department simulation applications for normal and disaster conditions. Comput. Ind. Eng. **1**(83), 327–344 (2015)
146. Dockins, J., Abuzahrieh, R., Stack, M.: Arabic translation and adaptation of the hospital consumer assessment of healthcare providers and systems (HCAHPS) patient satisfaction survey instrument. J. Health Hum. Serv. Adm. **1**, 518–536 (2015)
147. McDougal, T.R., Jr.: Emergency department wait time communication strategies and patient throughput efficiency. The University of Alabama at Birmingham (2015)
148. Ghanes, K., Jouini, O., Wargon, M., Jemai, Z.: Modeling and analysis of triage nurse ordering in emergency departments. In: 2015 International Conference on Industrial Engineering and Systems Management (IESM), 21 Oct 2015, pp. 228–235. IEEE (2015)
149. Bellamkonda, V.R., Kumar, R., Scanlan-Hanson, L.N., Hess, J.J., Hellmich, T.R., Bellamkonda, E., et al.: Pilot study of Kano "Attractive Quality" techniques to identify change in emergency department patient experience. Ann. Emerg. Med. **68**(5), 553–561 (2016)
150. Ganesan, V., Loftus, C.J., Hinck, B., Greene, D.J., Nyame, Y.A., Sivalingam, S., Monga, M.: Clinical predictors of 30-day emergency department revisits for patients with ureteral stones. J. Urol. **196**(5), 1467–1470 (2016)
151. Van der Linden, M.C., Meester, B.E., van der Linden, N.: Emergency department crowding affects triage processes. Int. Emerg. Nurs. **1**(29), 27–31 (2016)
152. Nezamoddini, N., Khasawneh, M.T.: Modeling and optimization of resources in multi-emergency department settings with patient transfer. Oper. Res. Health Care **1**(10), 23–34 (2016)
153. Nobel, R.: Retrial queueing models in discrete time: a short survey of some late arrival models. Ann. Oper. Res. **247**(1), 37–63 (2016)
154. Wachs, P., Saurin, T.A., Righi, A.W., Wears, R.L.: Resilience skills as emergent phenomena: a study of emergency departments in Brazil and the United States. Appl. Ergon. **1**(56), 227–237 (2016)
155. Leporatti, L., Ameri, M., Trinchero, C., Orcamo, P., Montefiori, M.: Targeting frequent users of emergency departments: prominent risk factors and policy implications. Health Policy **120**(5), 462–470 (2016)
156. Chaovalitwongse, W.A., Chou, C.A., Liang, Z., Wang, S.: Applied optimization and data mining. Ann. Oper. Res. **249**(1–2), 1–3 (2017)
157. Yazdanparast, R., Hamid, M., Azadeh, M.A., Keramati, A.: An intelligent algorithm for optimization of resource allocation problem by considering human error in an emergency department. J. Ind. Syst. Eng. **11**(1), 287–309 (2018)