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Significant changes in emergency department length of stay and case mix over eight years at a large Swedish University Hospital

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ABSTRACT

Objective: Describe the longitudinal development of crowding and patient/emergency department (ED) characteristics at a Swedish University Hospital.
Methods: A retrospective longitudinal registry study based on all ED visits with adult patients during 2009–2016 (N = 1,063,806). Patient characteristics and measures of ED crowding (ED occupancy ratio, length-of-stay [LOS], patients/clinician's ratios) were extracted from the hospital's electronic health record. Non-parametric analyses were conducted.
Results: The proportion of unstable patients (triage level 1–2) increased while the proportion of admitted patients decreased. All crowding variables were stable, except for LOS, which increased by 9 min/visit/year (95% CI: 8.8–9.1). LOS for visits by patients ≥ 80 years increased more compared to those 18–79 (248 min vs. 190 min, $p < 0.001$). Unstable patients increased their median LOS compared to stable patients (triage level 3–5). LOS for discharged patients increased with an average of 7.7 min/year (95% CI: 7.5–7.9) compared to 15.5 min/year (95% CI: 15.2–15.8) for those being admitted.
Conclusion: Fewer admissions, despite an increase of unstable patients, is likely related to lack of in-hospital beds and contributes to ED crowding. The increase in median ED LOS, especially for patients in the subgroups unstable, ≥80 years and admitted to in-hospital care reflects this problem.

1. Introduction

Emergency department (ED) crowding has for many years been identified as a major problem internationally [1,2]. Sweden has an increase in both number of ED visits and ED length of stay (LOS) the last decade [3]. However, previous studies of ED crowding have focused either on how to define [4] and measure crowding [5–10] or on causes of [11], effects of [12–15] and solutions for crowding [11]. Only one study, with a cross-sectional design, has tried to create an overview of the occurrence of crowding in 15 countries [2]. ED crowding is considered a threat to patient safety [16–18], has negative effects on patients' experiences of the quality of care provided [19] and for resulting in extended ED LOS for patients [12,15]. Finally, it also has negative effects on the clinicians' (physicians' and registered nurses' [RN]) workload [17] and work satisfaction [20].

There is a lack of a standardized definition and systematic measurement of crowding [21], which makes it difficult to compare the results of different studies and obtain an overview of the magnitude of crowding. One commonly used definition is: "*a situation in which the identified need for emergency services outstrips available resources in the ED, hospital or both* "[22]. That is, ED crowding should not only be related to the sheer number of patients in the ED, but also to factors like the number of clinicians on duty, distribution between triage acuity levels, number of patients waiting to be seen by a physician and number of available in-hospital beds [23]. According to a conceptual model by Asplin et al., [4], the ED system can be divided into three main components: input (e.g. patient inflow, chief complaints, and acuity levels), throughput (e.g. staff levels, staff workload, and access to treatment beds), and output (e.g. access to in-hospital beds and access to transport service) [4]. This widely used model provides a framework for better understanding ED crowding. The components input and output are most difficult for the ED to influence. For example, the group of elderly citizens (≥65 years of age) is constantly increasing, both in Sweden and internationally [24,25] and the prognosis is that in 2030 every fourth Swedish inhabitant will be over 65 years [24]. Approximately 40% of patients seeking ED care in Sweden are ≥ 65 years and are often in

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need of in-hospital admission [24]. Furthermore, it has been identified that patients ≥ 80 years have more extended LOS in the ED than other age groups [3]. Regarding output, Sweden is one of the countries in the Organization for Economic Co-operation and Development (OECD), with the least number of available in-hospital beds for somatic care in relation to its population (2.4/1000 inhabitants in 2015, compared to the OECD average 4.7/1000 inhabitants) [26]. Only South Africa, Brazil, Chile, Colombia, Mexico, Indonesia and India have fewer. The figures for Canada and United Kingdom are 2.6/1000 inhabitants respectively, 2.8/1000 inhabitants for United States and 3.8/1000 inhabitants for Australia. Both, Sweden and the Anglo-Saxon countries mentioned above have all decreased their number of available in-hospital beds in relation to their populations since year 2000. These figures can be compared to Japan, that has the highest number of available in-hospital beds/1000 inhabitants among the OECD countries with 13.2 [26].

In the literature, several ED crowding indicators has been used. Examples are *ED Occupancy Ratio* (EDOR) [7], *ED work score* to predict ambulance diversion [6], *ED work index* (EDWIN) [5], *National ED overcrowding scale* (NEDOCS) [9], *overcrowding hazard scale* [8] and *Skåne Emergency department Assessment of patient Load* (SEAL) [10]. ED LOS (i.e., the time interval from registration until the patient leaves the ED either as discharged or admitted to in-hospital care) is sometimes used as a measure of crowding [13] and sometimes as an outcome measure of crowding [14]. Among these measures, LOS and EDOR are the most commonly used. Although EDOR is only a value of how many patients are present in the ED in a certain time period divided by the number of established treatment beds (fixed number) in the ED, with crowding defined as a ratio > 1.0. This way of measuring crowding does not take clinician/patient ratios into consideration, which is the case in some studies of in-hospital care [27].

Numerous studies indicate that ED crowding is a worldwide problem, affecting the ED working conditions and the possibilities of delivering safe care of good quality. However, these studies have either focused on how to define and measure crowding or on causes, effects of and solutions to crowding. Thus, there seem to be a knowledge gap about the presence of crowding over time, since, to our knowledge, no previous study has had a longitudinal design. There is also a knowledge gap concerning ED crowding at the patients per clinician ratio-level. Therefore, this study aims to describe the longitudinal development of crowding and patient and ED characteristics at a Swedish University Hospital over an eight-year period.

2. Methods

2.1. Study design, setting and sample

This retrospective longitudinal study is based on ED visits at the Karolinska University Hospital during calendar years 2009–2016. With its two ED sites, this is one of four emergency hospitals in Stockholm, Sweden, which has approximately 2 million inhabitants. Both sites host their own EDs for adults with approximately 77,000 (site 1) and 73,000 (site 2) ED visits respectively per year. Both EDs see patients with internal medicine, surgical, orthopedic, neurological and infectious conditions. Site 1 is also a level one trauma center and sees patients with ear-nose- and throat complaints and patients with ongoing oncologic treatments. The Rapid Emergency Triage and Treatment System (RETTS) is used at both EDs [28]. RETTS is a five-level triage scale descending from red (1) to blue (5), where red (1) represents the most urgent level – i.e. patients in need of immediate medical attendance. Patients with triage levels red (1) and orange (2) are classified as unstable, in contrast to the stable group consisting of levels yellow (3), green (4) and blue (5). All ED visits by adults (≥18 years) to the University Hospital during the period January 1, 2009–December 31, 2016 were included in the study. Exclusion criteria were patients with gynecological conditions, since these sections of the EDs are staffed by their own clinicians and are thus not part of the regular EDs. The reason for this study period is that since 2009 it is possible to extract data from the electronic health record (EHR) system.

2.2. Measurements

All data in the study is based on registry data. The hospital holds a central data warehouse, (KARDA) which draws data from the EHR every 24 h, containing information from the EHR since 2009. This makes it possible to collect data on all ED visits to the hospital on a minute-to-minute basis. The following variables were programmed and collected for each ED visit, for example; age, gender, chief complaint, arrival mode, triage acuity level, age-combined Charlson's Comorbidity Index (ACCI) [29], ICD 10-codes, date and time of arrival/discharge from the ED, time to first assessment by a physician and admitted to in-hospital care or not. The ED crowding indicators investigated are; ED LOS, EDOR, RNs/physicians per patient ratio (i.e. number of unique caregivers responsible for each patient during a patient ED visit, presented for each profession separately) and patients per RNs/physician's ratio (i.e. number of patients each unique clinician is responsible for in a given time slot, presented for each profession separately). The two variables related to ratios were created by the research group. Information about EDOR, RNs/physicians per patient ratio as well as patients per RNs/physicians' ratio was extracted from the central data warehouse in two-hour slots. The reason for choosing two-hour slots was that we wanted as short a time interval as possible in order to capture the fluctuations in ratios, but still be able to handle the large amount of data.

All variables used in this study have been validated by the first author (LMB) together with a systems scientist at the Department of E-Health and Strategic IT at the University Hospital. For example, parts of the extracted data manually entered in the EHR have been compared to actual patient information in the EHR in order to validate the programming codes for extraction. The extraction of data and validation of the variables have been discussed continuously within the research group during the validation process.

2.3. Statistical analyses

All discrete data were presented as numbers and percentages and continuous data as medians (IQR) due to lack of a normal distribution of the data. Non-parametric analyses have been used. Chi square test was used to investigate differences in proportions of ED visits for males vs. females and age groups 18–79 vs. ≥80 in relation to triage levels. Wilcoxon Rank Sum test was used when investigating differences in the distribution of LOS for the same age and gender groups as well as for triage levels. Quantile regression analysis was used to model the trend in median LOS, EDOR and patients per RNs ratio over time. Statistical significance was set at $p < .05$. The analyses were based on ED visits and not on unique patients (N = 1,063,806), except for EDOR, which was based on two-hour slots (N = 35,064), i.e. 12 slots for each date during the period 2009–2016. During the period 13/12 2009 – 20/4 2010 there was a technical problem in the data source concerning the registration of the responsible physician for each ED visit, which affected the analyses for "patients per physician's total average" in Fig. 3. Therefore, all ED visits during this period (n = 42,121) were excluded from this analysis. All statistical analyses were performed with Stata, version 14.1 (StataCorp, College Station, TX).

2.4. Ethical considerations

The Regional Ethical Review Board in Stockholm approved the study (2016/1164-31) and the management of the EDs gave their permission. All data in the study is presented on a group level and cannot be linked to a specific patient.

Table 1
Demographic ED data for the participating EDs at a Swedish University Hospital during the study period.

	2009	2010	2011	2012	2013	2014	2015	2016
Number of ED visits (n)	116,080	125,967	136,128	139,085	136,171	140,004	137,184	133,457
Patients' age median, Years (IQR)	51 (34, 68)	51 (34, 68)	51 (34, 68)	51 (34, 68)	51 (34, 68)	50 (34, 69)	51 (34, 69)	50 (33, 68)
Sex female n (%)[a)]	58,411 (50.3%)	63,912 (50.8%)	69,393 (51.0%)	71,176 (51.2%)	69,499 (51.0%)	71,432 (51.0%)	69,824 (50.9%)	67,332 (50.5%)
Prevalence of top three chief complaints (dyspnea, chest pain and stomach pain) n (%)	24,652 (21.2%)	29,242 (23.3%)	32,220 (23.7%)	33,420 (24.0%)	32,849 (24.1%)	34,597 (24.7%)	33,615 (24.5%)	32,404 (24.3%)
Arrival with EMS[d)] transport n (%)	24,236 (20.9%)	26,491 (21.1%)	29,241 (21.5%)	30,391 (21.9%)	30,598 (22.5%)	30,844 (22.0%)	30,797 (22.4%)	27,904 (20.9%)
Triage level n (%)[b)] [c)]								
Red (1)	5549 (4.8%)	5574 (4.4%)	6047 (4.4%)	7188 (5.2%)	7733 (5.7%)	8088 (5.8%)	7298 (5.8%)	7768 (5.7%)
Orange (2)	11,750 (10.1%)	14,089 (11.2%)	15,665 (11.5%)	16,897 (12.1%)	16,293 (12.0%)	17,641 (12.6%)	18,506 (13.5%)	19,245 (14.4%)
Yellow (3)	29,323 (25.3%)	34,825 (27.7%)	37,658 (27.7%)	44,964 (32.3%)	47,530 (34.9%)	52,774 (37.7%)	55,532 (40.5%)	55,392 (41.5%)
Green (4)	41,999 (36.2%)	45,248 (36.0%)	51,425 (37.8%)	46,711 (33.6%)	41,545 (30.5%)	40,192 (28.7%)	35,054 (25.6%)	28,001 (21.0%)
Blue (5)	25,487 (22.0%)	24,235 (19.3%)	23,502 (17.3%)	21,002 (15.1%)	20,897 (15.3%)	18,851 (13.5%)	17,328 (12.6%)	19,939 (14.9%)
ACCI [e)] –point median (IQR)	0 (0,3)	0 (0,3)	0 (0,3)	0 (0,3)	0 (0,3)	0 (0,3)	0 (0,3)	0 (0,3)
Time of arrival n (%)								
Day (7 a.m. – 3:59p.m.)	67,744 (58.4%)	72,443 (57.6%)	77,774 (57.1%)	79,245 (57.0%)	77,652 (57.0%)	79,522 (56.8%)	77,207 (56.3%)	75,276 (56.4%)
Evening (4p.m. – 8:59p.m.)	27,732 (23.9%)	29,629 (23.6%)	32,179 (23.6%)	32,971 (23.7%)	31,953 (23.5%)	33,179 (23.7%)	32,880 (24.0%)	31,946 (23.9%)
Night (9p.m. – 6:59 a.m.)	20,604 (17.7%)	23,625 (18.8%)	26,175 (19.2%)	26,869 (19.3%)	26,566 (19.5%)	27,303 (19.5%)	27,097 (19.8%)	26,235 (19.7%)
Admitted to in-hospital care within 12 h n (%)	30,476 (26.25%)	33,784 (26.88%)	35,426 (26.02%)	35,102 (25.24%)	32,963 (24.21%)	33,677 (24.05%)	32,006 (23.33%)	29,282 (21.94%)

[a)] 3733 missing during the entire study period.
[b)] Based on the five-level triage scale RETTS© where triage level "Red (1)" represents the most urgent level i.e. in need of immediate medical attendance.
[c)] 18,531 missing during the entire study period.
[d)] Emergency Medical Services, i.e. ambulance or helicopter staffed by paramedics.
[e)] Age Adjusted Charlson Co-Morbidity Index, points on a scale from 0 to 34.

3. Results

A total of 1,063,806 eligible ED visits to the hospital took place during the study period (Table 1).

3.1. Patient characteristics

The gender distribution was even in all eight years (Table 1). However, men were more often triaged as red or orange acuity ratings compared to females (19.3% vs. 16.4%, $p < 0.001$). Of the top five chief complaints, the top three were consistent for all eight years, i.e. abdominal pain, which was most prevalent, followed by chest pain and dyspnea. Chief complaint numbers four and five varied between three different complaints during the study period, that is headache, swelling/pain in extremity and fever. Together, the six most common chief complaints constituted 36% of all chief complaints, and non-defined chief complaint constituted 7%.

Most variables in Table 1 were constant over time. However, the number of ED visits in 2009 was 17,377 fewer than in 2016. In 2014, the annual number of ED visits started to decline, but has yet not reached the baseline level in 2009. The proportion of ED visits leading to in-hospital care has decreased each year, from 26.3% to 21.9% ($p < 0.001$). During the study period, there has been a constant increase in patients triaged as unstable in their health condition (triage acuity level red/orange), and a decrease in those triaged as stable (yellow/green/blue). In 2009, 14.9% of the patients were triaged as unstable, compared to 20.2% in 2016 ($p < 0.001$).

The distribution between the age categories (18–39, 40–64, 65–79 and ≥80 years) has been stable over the study period, apart from a minor transition from patients in the group ≥80 years to the age group 65–79. Patients ≥80 years were represented more in the triage level group red/orange compared to patients aged 18–79 (29% vs. 16%, $p < 0.001$).

3.2. Trends for LOS

During the study period, there has been an increase in median LOS, with an average of 9 min per visit on an annual basis (95% CI: 8.8–9.1) (Fig. 1). Median LOS for all ED visits increased by 59 min from 2009 to 2016 (175 min vs. 234 min). Female patients had a longer median ED LOS than male patients (203 min vs. 189 min, $p < 0.001$). Furthermore, there was an increased median LOS for patients ≥80 years compared to the age group 18–79 (248 min vs. 190 min, $p < 0.001$).

There is a trend of an average increase of 11.6 min/year (95% CI: 11.2–11.9) in median LOS for the group of unstable patients over the study period compared to the group of stable patients which have only

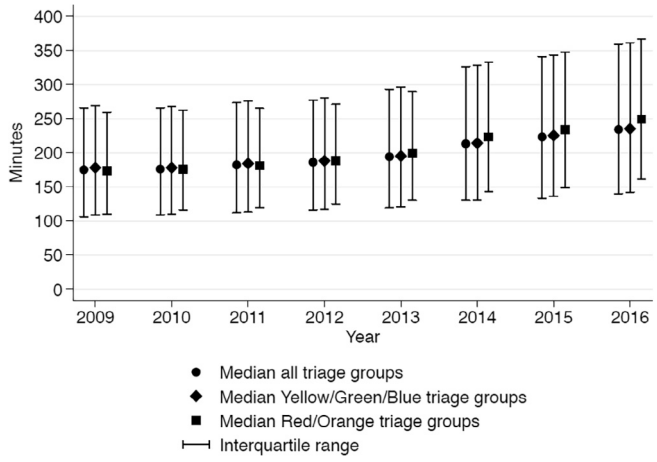

Fig. 1. Median LOS in minutes grouped as unstable (triage level red/orange) and stable (triage level yellow/green/blue) patients.

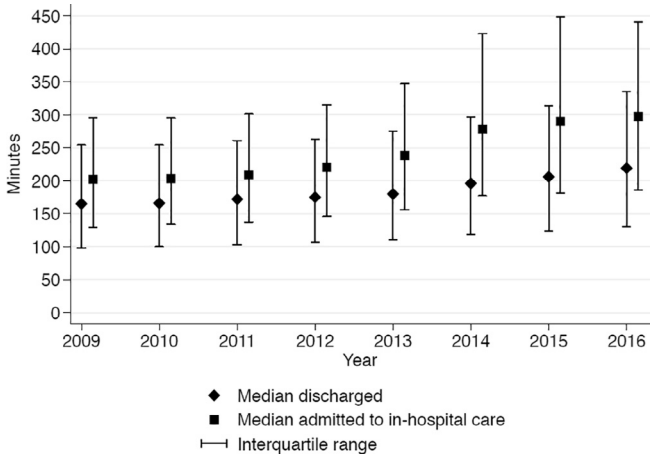

Fig. 2. Median LOS in minutes grouped as patients discharged from the ED and admitted to in-hospital care within 12 h.

increased by an average of 8.7 min/year (95% CI: 8.5–8.8) (Fig. 1). The largest increase occurred among patients triaged in the second most urgent triage acuity level (orange), with an average increase of median LOS by 11.8 min/year (95% CI: 9.4–10.6). The smallest average increase of median LOS, 1.5 min/year (95% CI: 1.2–1.8), occurred among patients triaged as level blue, i.e. the least urgent triage acuity level. Furthermore, patients with triage level blue had a median LOS of 124 min compared to 159 min for triage level red, i.e. the most urgent triage acuity level.

Patients discharged from the ED have increased over the study period, from 85,604 (73.8%) visits in 2009 to 104,175 (78.1%) in 2016. In contrast, the number of patients admitted to in-hospital care have decreased from 30,476 (26.3%) in 2009 compared to 29,282 (21.9%) in 2016. Median LOS for the group of patients discharged was 54 min longer in 2016 than in 2009, while the median ED LOS for the group admitted to in-hospital care was 95 min longer (Fig. 2).

Thus, when testing for trends in median LOS over the study period for the two subgroups discharged or admitted to in-hospital care, we found an average increase of 7.7 min/year (95% CI: 7.5–7.9) for the patients discharged from the ED. This is compared to the group of patients admitted, which have increased their median LOS by an average of 15.5 min/year (95% CI: 15.2–15.8).

3.3. EDOR, RNs/physicians per patient and patients per RNs/physicians ratios

The median, as well as percentile 25 and percentile 75, for three of four ratios have been stable over the study period. Only the measurement median patients per RN ratio has increased, with an average increase of 0.164 patients/RN/year (95% CI 0.162–0.167; $p < 0.001$) (Fig. 3). Furthermore, the median (p50) for EDOR during the study period has increased from 0.8 in 2009 to 1.1 in 2016, which is an increase with 0.04/year (95% CI 0.040–0.047; $p < 0.001$).

4. Discussion

This study is, to our knowledge, the first that has used a longitudinal design for studying ED crowding, which has made it possible to identify changes in crowding and ED characteristics over time. To summarize the main results; the median for all crowding variables have been stable over the study period, except for LOS where the median has increased. The largest increases in median LOS occurred among unstable patients, patients ≥80 years and those admitted to in-hospital care. Furthermore, there has been a change in patient case mix, primarily with an increase in unstable patients.

LOS is the only crowding indicator in this study that shows an

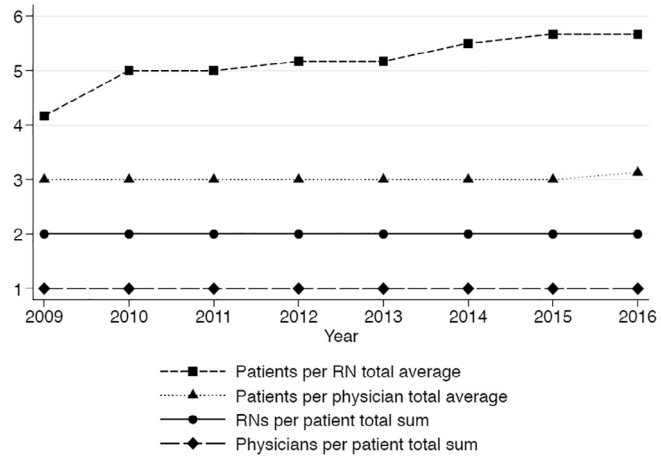

Fig. 3. Crowding ratios in ED visits from 2009 to 2016, reported as median.

increase in crowding, with trends of increasing median LOS for all groups analyzed. EDOR, clinicians/patients and patients/clinician's ratios were stable over the years and did not capture the increase in ED visits. However, it is still possible that an increase in crowding has occurred, but we may not have been able to capture the increase through these measures. During the study period, the proportion of unstable patients increased, indicating that patients seeking ED care might be more severely ill when arriving at the ED in 2016 than in 2009. Furthermore, as patients ≥80 years were represented to a greater extent in this group, our data suggest that the group of vulnerable and frail patients in the ED has increased. Despite this, the proportion of in-hospital admissions decreased during the study period, and the yearly increase in median LOS for patients admitted was twice as high as for patients discharged. The increased median LOS for all ED visits (72 min during the study period) is consistent with figures from annual Swedish reports since 2011 of waiting times at five Swedish EDs [3,30]. However, the accumulated increase of LOS during the reviewed periods is about 50 min. The groups of patients especially affected by the increasing LOS are the most vulnerable and frail patients, i.e. the unstable patients and patients ≥80 years. The negative effects of an increased LOS on elderly patients is well known from previous reports and studies (3). The prolonged stay in the ED may be caused by the fact that unstable and older patients more often need admission to in-hospital care and, therefore, need more extensive investigation in the ED before a treatment plan is set.

Both fewer admissions and increased ED LOS are closely related to the lack of in-hospital beds and our findings are indicating that the EDs have an output problem related to this lack. A major plan to reform Swedish healthcare is ongoing over recent decades, where one goal is to transfer some of the in-patient care to care to outpatient clinics. One part of the transition from in-hospital care to the provision of care outside hospital has been to reduce the number of in-hospital beds. This decrease of in-hospital beds, together with the challenge to staff wards with RNs, has created a shortage of available in-hospital beds at all Swedish hospitals, creating an output problem for the Swedish EDs [31]. This is one part of the problem with ED crowding, and Swedish healthcare organizations have tried to deal with the lack of available in-hospital beds in different ways. Within the Stockholm region, one solution which affects input is that as much care as possible should be delivered by care givers in the primary health care network. The primary reason is to deliver care at the most effective level [31]. This solution is primarily for patients among the lowest triage levels, which are considered stable. A throughput strategy has been to create fast tracks inside the EDs for these patients if they still need ED care [32], a solution recognized by the Swedish National Board of Health and Welfare to affect LOS in a positive way [3]. However, none of these solutions are targeting output. Our results show that patients with the second most urgent triage level (orange) have increased their median LOS by 94 min during the study period compared to 12 min for the patients with the least urgent triage level (blue). Thus, according to our study, this previously mentioned focus on input and throughput primarily seems to benefit the group of patients with the lowest urgency, which is the group with the least need of ED care.

The groups of patients that have the longest median LOS (unstable and ≥80 years) often have greater care needs compared to those with the lowest triage levels and < 80 years. This increased care need creates a greater workload for the ED clinicians, even if the EDOR or patients per clinician's ratios have not increased. Also, unstable and older patients more often need admission to in-hospital care. The increase in LOS for patients that need to be admitted turns the EDs into in-hospital wards. This creates patient safety risks and stress among staff, since the EDs are not designed, dimensioned or staffed for that mission (3). These factors combined might create a perception among clinicians that the EDs are more crowded. One way to take this perception into consideration is to include the clinicians' perception of workload into a crowding measurement tool. One Swedish measure of crowding has taking this perspective into consideration [10]. However, it is difficult to measure workload in a more objective way without implementing valid tools for patient classification, such as the Jones Dependency Tool [33]. This kind of tool must also be supported by the IT-systems for extraction of data.

4.1. Limitations

There are some limitations that need to be addressed concerning internal and external validity. The data quality is of key interest in registry studies. Due to the human factor, there is a potential risk that variables entered manually in the EHR are less valid than those that are generated automatically, such as age, gender and date for mortality. In order to deal with this, the manually entered variables have been carefully reviewed during the validation process, foremost through the first author's knowledge of the clinical setting and of how patient data is registered in the EHR, which made it possible to estimate the reliability of the data and identify potential sources of error for further scrutiny. There have also been some challenges regarding the development of the crowding variables that concerns ratios. For example, each individual clinician was only counted once, even if the clinician was registered as involved in care on more than one occasion during a patient's ED visit. This might have affected the clinicians per patient ratios, in that some of the extracted ratios were slightly lower than actual ratios. Another limitation related to the ratios is that data was collected in two-hour intervals, which leads to some potential lack of detail that might have been detected on, for example, a 30-minute interval. However, we still think that it has been possible to capture possible fluctuations concerning ratios, and since the study spreads over eight years, it would be difficult to handle data at a lower level of abstraction than two hours. Regarding external validity, the organization was essentially unaltered concerning staffing and how ED work was organized during the study period. The results are likely to be generalizable to other EDs in a Swedish context, since the demographic in Stockholm is similar to the rest of the country, apart from a slightly lower proportion of citizens ≥65 years in Stockholm. However, to be able to say that the results are generalizable to EDs internationally, further studies with a longitudinal design need to be conducted in other countries.

5. Conclusions

To conclude, the transition in case mix towards more patients with unstable health conditions indicates that the EDs to a large extent handles the group of patients in most need of ED care. The largest increases in median LOS took place in this group of patients, patients ≥80 years and those in need of admission to in-hospital care. This

indicates that the biggest problem with ED crowding is related to the output, since all these groups to a large extent are in need of in-hospital admission. Focus on the throughput should be to reduce time not useful to the patient and find solutions to improve output. All EDs should provide safe and evidence-based care of high quality. To be able to fulfil this goal to older and/or severely ill patients with prolonged LOS, these factors must be considered when planning future EDs regarding staffing, level of competence, work organization, education and design of ED premises.

Conflict of interest

None declared.

Ethical statement

The Regional Ethical Review Board in Stockholm approved the study (2016/1164–31).

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