Original Contribution

Choosing wisely in the ED: The diagnostic cascade of needless medical testing in a two-level study☆

Mor Saban [a,b,*], Barniv Hava [c], Patito Heli [b], Shachar Tal [d], Haber Reuben [b], Salama Rabia [b], Darawsha Aziz [b]

[a] Department of Nursing, The Faculty of Health and Welfare Sciences, University of Haifa, Haifa, Israel
[b] Rambam Health Care Campus, Haifa, Israel
[c] Clalit health service, 3498838
[d] The Azrieli faculty of Medicine, Bar-Ilan University, Safed, Israel

ABSTRACT

Background: The diagnostic cascade in the emergency department (ED) has not been fully elucidated.
Aim
To inspect whether the usage of consulting medicine and imaging contributes to hospital outcomes. We also propose a theoretical model for better understanding the diagnostic cascade of needless medical testing.
Methods: A two-level study was conducted. The first local phase was a retrospective archive study that was conducted between 2014 and 2017 in a tertiary hospital. We extracted the number of requested imaging and consultations for each patient, and main time lags were calculated. The second-phase (January–April 2018) was conducted on a national level. We examined 22 hospitals with the emphasis on five hospital outcomes: recurrent ED visits (within 24 h), median waiting time at the ED, rate of early discharge at the same day and day after and percentage of patients spending >4 h in the ED.
Results: A 5% upsurge in CT scans was observed ($p = .032$), and a significant increase was found in the number of consultations (14%, $p = .002$). On a national level, a linear regression model found that the proportion of patients discharged from the hospital on the same day and on the day after and the proportion of patients staying in the ED > 4 h predict ED recurrence visits within 24 h ($p = .025$; $R^2 = 46.3\%$).
Conclusions: Upsurge in resource usage in the ED leads to a diagnostic cascade of health consumption. Further study is necessary to examine the proposed model in a global scale.

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Introduction

For over two decades emergency departments (ED's) have been plagued with poor quality of care outcomes [1]. ED crowding is a prevalent and important issue concerning hospitals all over the world [2,3]. Reasons for ED overcrowding that are relevant for this research are increased patient volume [4], increasingly complex patients [5], non-urgent use of ED and "access block" [4,6]. Access block is a frequently related concept to ED overcrowding [3,6,7]. It is a term defined as the inability of patients in the ED to gain access to in-patient beds in a certain time lag or the time it takes to be admitted, transferred or discharged.

Access block leads to ED overcrowding and results in poor outcomes [7]. Simultaneously, over the years, health consumer behavior has changed and become more socially aware [8,9]. One major reason for this phenomenon is extensive waiting time for consulting medicine [10]. This behavior has led health consumers to seek alternative means of treatment, i.e. shorter queues found in the ED. [11,12]

Non-urgent ED visits are common and comprise 37% (Range 8%–62%) of all ED visits [13,14]. Several reasons for this phenomenon are convenience (i.e. ease of use), dissatisfaction from community alternatives, poor access to consulting medicine and imaging outside the ED, in part due to long waiting times [13,15]. Over the years, ED consultants became an integral part of the ED staff [10,12,16], Taking part in admitting patients along with ED emergency specialists [16]. These consultants comprise mainly of general surgeons, orthopedic surgeons and internists, which cover most of ED visits [17], while working in collaboration with other specialists, such as neurologists, psychiatrists, urologists etc. A systematic review included five papers that inspected consultation proportion at ED and found variance of 20% to 40% for all patients [18]. The rate of consultations in the ED has increased substantially to a point where it affects Length of Stay (LOS) [17]. However,

none of these studies portrayed the time trends of consultation rates. Concurrently, diagnostic imaging, especially computed tomography (CT) scans, are common and have increased substantially over the years in the ED setting [19]. Overall rate of imaging studies has risen by >60% [20]. Broder and his colleagues showed that the rates for various types of CT's has increased by 51%–463% over a period of 5 years[21]. A study published previously by Yoon and his colleagues pointed out the positive correlation between imaging and LOS at ED. [17] To support this publication, recent studies found that 40% -60% of the diagnostic tests that are performed during hospitalization are unnecessary [22,23]. Needless tests can cause patient discomfort, patient harm, increase healthcare costs and also lead to false positive results which initiate a cascade of other tests, a phenomenon known as a diagnostic cascade [24].

However, this diagnostic cascade was not evaluated in the ED setting and no updated data is available to show the current incidence state of diagnostic imaging in a time ED overcrowding becomes a worldwide phenomenon. Furthermore, implantation of intervention programs to reduce overuse of health resources such as "choosing wisely" are not common in the ED setting.

Thus, the aim of this study is to inspect whether the usage of consulting medicine and imaging influences waiting times and access block in the ED, as well as to emphasize the urgent need for implementation of resource optimization programs in the ED worldwide. We also formulate a theoretical model that illustrates the diagnostic cascade of needless medical testing in the ED.

Methods

Study design and setting.

A two-level study was conducted. The first local phase is a retrospective quantitative archived study that was performed from January 2014 to April 2018 in a tertiary hospital. The hospital is a 1000-bed academic hospital serving over 2 million residents of Northern Israel. The ED is based on three main medical sectors (orthopedic, surgical and internal) defined as case managers and are regarded as ED staff. The ED staff rotate daily and are under the supervision of their department. During early morning and late evening hours there are three ED specialist that serve as internal specialists. Most of the patients (75.4%) are examined and processed directly by these departments, whereas internal physicians examine majority of patients (41.8%), surgical physicians examine 14.8% of the patients and the remaining (19.1%) are examined by orthopedic physicians.

In other cases (24.6%) patients arrive with a specified case such as: signs of stroke, single localized burn, nose trauma, corneal foreign body, vaginal bleeding and with a direct referral from a specialist physician (neurologist, plastic surgeon, ear, nose, and throat (ENT), optometrist and gynecologists). Physicians such as: urologists, ENTs, rheumatologists, cardiologists, hematologists, gynecologists, plastic surgeons, optometrists, cardiac and thoracic surgeons, oral and maxillofacial surgeons, psychiatrists, neurosurgeon, oncologists, nephrologists and dermatologists, are regarded as consulting physicians and can assist ED staff in patient care. Such collaboration is referred as consulting medicine.

Data collection.

Data was extracted from the electronic medical record (EMR). The ED contains 105 beds and about 100,000 patients >18 years old are treated per year on average.

In the second phase we examined the effect of the common use of consultation and imaging on a national level ($n = 22$ hospitals), between 2011 and 2016. We included only tertiary and secondary hospitals with annual ED visits above 55,000 patients. We focused on five outcomes: recurrent ED visits (within 24 h), median waiting time at the ED, percentage of patients spending >4 h at the ED and the rate of early discharge (on the same day and the day after). Charlson score was assessed as a covariate. The Charlson comorbidity index has been

a useful tool for health researchers in their effort to measure comorbid disease status or case mix in health care databases [25,26].

Methods and Measurements.

The study sample for phase 1 consisted of 392,919 patient files who were retrieved from the ED EMR during the study period. The data was collected retrospectively in January–April 2018 using a data sheet by the first and the second authors. For each patient we collected the following number of consultations and imaging tests ordered (X-ray, US, CT), and calculated the rate changes during the years.

ED physician staff (internal, surgical and orthopedic) can admit patients independently of consultant involvement only to their respective departments. If they wish to admit patients to other departments it requires a consultation with the relative physician.

In addition, for each patient we assessed the time to triage, time to physician, time to decision, total time in ED, mean waiting time, hospitalization rate and in-hospital length of stay. In the second phase, we examined the phenomenon on a national level among 22 hospitals to find out whether the upsurge in consultations and imaging affects the aforementioned five outcomes. Data was collected from the national registry during 2011–2016. For each hospital we collected the ED visit rate, recurrent ED visits (within 24 h), median waiting time at the ED, percentage of patients spending >4 h at the ED and short hospitalization rate (discharge at the same day or discharge the day after). Due to the influence of morbidity on hospitalization rate we also collected data from the national registry in the scope of the Charlson score.

Data Management and Statistical Analysis.

Descriptive statistical analyses were performed for ranges, means, and standard deviations for continuous variables and frequencies and percentages for categorical variables. Chi square test or one-way ANOVA were used when appropriate to compare between means, Pearson analysis was performed to examine the following correlations: number of patients and waiting time; number of patients and number of imaging tests; number of patients and number of consultants; number of consultations and hospitalization rates. Two linear regression models were performed to predict ED waiting time and hospitalization rate by number of consultations and imaging tests. Poisson regression was performed to predict LOS by imaging tests and number of consultations. The level of significance for all statistical analysis was 5%. The data analysis was performed using the Statistical Package for Health & Welfare Science for Windows (SPSS, version 23.0, Chicago, IL, USA).

Results

During the first study period, the number of patients admitted to the ED increased by 15%. Admission rate is on a rising trend (2014–32% whereas at 2017 it stands on 42%), while ED admission rate in the local hospital is the highest in the country compared to the national rate which stands at 22%.

We observed a significant statistical decrease in time to triage (from 26.0 ± 1.81 in 2014 to 12.0 ± 2.89 min in 2017, $p < .001$) and time to physician (from 81.0 ± 12.6 in 2014 to 65.4 ± 18.0 min in 2017, $p < .001$). In contrast, time to final decision and total time in ED increased from 249.6 ± 41.9 min in 2014 to 264.0 ± 52.2 in 2017 and 558 ± 410.4 min in 2014 to 594 ± 430.8 in 2017; respectively (Table 1).

Data of resource consumption from 2014 to 2017 showed a significant increase in the number of consultations. The number of consultations has risen from 117,109 in 2014 to 149,724 in 2017 ($+14\%$; $p < .001$). We also observed an increase in all types of CT scans (5%, $p = .032$). We observed an increase (5%, p = .032) in head, spinal, chest, abdomen and pelvic CT, as well as total body complete tomography in trauma cases. The number of X-ray tests decreased significantly (11%, $p = .021$), whereas no significant change was found in US tests (Table 2).

A strong positive correlation was found between number of consultations and CT scans to total ED waiting time ($r = 0.99$, $p \leq .001$; $r = 0.97$, p ≤ 0.001; respectively). We also found strong positive correlation

between CT scans order in ED in hospitalization rate ($r = 0.942$, $p = .051$; Fig. 1), as well as between number of consultations and hospitalization rate ($r = 0.935$, $p = .045$; Fig. 2). The inpatient bed availability has not changed during the study period.

On a national level, we found an increase of 16% in ED visits during the study period (2012–2016). On average, 120,100 patients are admitted to the ED annually, while the busiest ED treated 234,500 patients (hospital 1). The recurrence of ED visits within 24 h raised from 3% in 2012 to 3.55% in 2016, and the median waiting time at the ED was 2.74 h (0.29 h increase). The national percentage of patients who spent more than four hours in the ED has significantly increased (from 23.7% in 2012 to 33.4% in 2016, $p < .01$). During 2012 and 2016, the proportion of discharge at the same day and the day after was 10.71% ($+0.29\%$) and 34.50% ($+1.65\%$) respectively. No significant differences were found in the Charlson index between the hospitals during the years.

On a national level, a linear regression model found that the percent of patient discharge from hospital at the same day and the day after, and the percent of patient stay at the ED > 4 h predict significantly ED recurrent visits within 24 h ($p = .025$; $R^2 = 46.3\%$).

Discussion

The upsurge of needless medical testing in ED's is an important universal issue. This study examined whether the usage of consulting medicine and imaging contributes to ED boarding and access block. Although we observed a significant decrease in times for the initial assessment, the time for final decision and total waiting time increased intensely. These trends are universal and waiting times in EDs are a considerable problem in many countries [25,26]. The main explanation may be due to the noticeable increase in CT imaging tests and consultations, with most ED examinations were aimed to verify the diagnosis and prepare the patient for admission. As evidence, most patients who underwent CT scans were hospitalized (90%).

Previous studies suggested that there has been a tremendous increase in utilization of advanced imaging despite little evidence to suggest associated improvement in patient outcomes [21,27]. For example, Kanzaria and his colleagues claim that over-imaging is a systemic problem, that led to over diagnosis which in turn led to overtreatment resulting in substantial harm [27]. A recent study of 5 million fee-for-service Medicare beneficiaries from USA found that increased regional CT risk was associated with a higher nephrectomy risk ($r = 0.38$; 95% CI, 0.28–0.47) [28].

The etiology of this increase is well investigated, considered as multifactorial and may include malpractice fear, desire for diagnostic certainty, lack of or inconsistent clinical decision instruments and their poor adoption, inadequate training in evidenced-based medicine, slow knowledge translation, perverse financial incentives, requests of consulting and referring physicians, and increased practice intensity and overall complexity of emergency care [27,29-31].

The current literature shows that the use of consultations is present in 20–60% of all ED visits [32,33]. We also found positive correlation between CT scans ordered in the ED and hospitalization rate, as well as between the number of consultations and hospitalization rate. Previous studies identified that diagnostic tests and consultations have a major effect on admission characteristics. Waiting time to see a physician, diagnostic imaging and laboratory tests were associated with longer LOS [32-34]. A different research found that admitted patients receiving consultations in the ED had a longer overall LOS compared to discharged patients. Linear regression modelling revealed that multiple consultations were significantly associated with longer LOS [35]. Other studies also showed the impact of consultation decision times on LOS and the elongation of LOS due to multiple consultations [36,37].

In contrast, increase in availability of consulting medicine found to be effective for the ED setting by reducing 30-day in-hospital mortality

and prediction of survival [38]. Another study found that with reduced consultant availability there are worsened outcomes at the ED, and suggested that the increasing patient volume with current ED medical and nursing staff requires more consultants, both in numbers and availability [39]. Hospitalization is more likely for patients receiving consultation, although this is highly confounded by illness severity. However, our results did not find any changes while controlling illness severity for the Charlson score.

Considering the previous data we acquired and demonstrated, we propose the following theoretical model (Fig. 3). The model illustrates the diagnostic cascade of needless medical testing in the ED. Rise in ED visits lead to a combined effect of needless medical testing and defensive medicine which is characterized by an increase in consultations and imaging tests (with an added synergistic effect). In this scenario the likelihood of pathological findings is increased. Due to high variability of the findings further consultations and imaging tests might be ordered. The aforementioned leads to a prolonged stay in the ED and therefore an upsurge in ED boarding and access block. The hospitalization rate is influenced by the rise of patients waiting to be hospitalized. Rise in hospitalization rates, little to no increase in hospital beds and access block in the ED forces short hospitalizations. In the patient's eyes short hospitalizations are deemed incomplete and as such lead to recurrent visits to the ED.

Limitation.

This study has several limitations. The first limitation is a methodological one; most of the second phase data has been taken from preexisting public records and did not undergo data supervision by us. However, the data did undergo supervision with ordered and supervised methodology as well as random checkup of over 30% of the collected information. In addition, we do not have information regarding similar patients who did not undergo CT or consultation. It is possible to compare patient ED stays between those who had either CT scans or consult from previous years. However, systemic review found that hospitalization for patients receiving consultations in the ED indicate a high percentage of admissions among consulted patients. The third limitation would be that not every examination (imaging or consultation) has been examined to ensure it they are indeed justified. On the other hand, the rise demonstrated in the study, mainly in the CT and consultation aspect is relevant beyond any doubt and therefore requires a thorough analysis. The fourth limitation is that a retrospective study does not allow the long-term follow up of the patient's outcome due to needless medical testing. Nevertheless, the study is a one of a kind, mostly innovative and offers a theoretical model to examine this phenomenon in a larger scale in the long-term.

Conclusion

In recent years resource usage in the health care departments has increased dramatically. Our two-level ED study demonstrated the increased usage of needless medical testing leading to exhaustion of hospital resources, prolonged times for medical decisions, patient discharge and patient stay at the ED. The theoretical model we propose illustrates the diagnostic cascade of needless medical testing and can be useful in emphasizing and hopefully resolving this phenomenon as well as assist achieving clinical certainty on a global scale.

Author contributions

All authors interpreted the data and edited and approved the final article. MS and HB drafted and conceived the study. MS, HP and TS designed the intervention. MS, TS, HP, RS and AD analyzed the data, designed the study and performed data collection. MS and HB take responsibility for the paper as a whole.

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