Defining crowding -

in emergency departments by measures and outcomes

Term Paper

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1 Introduction

1.1 Background

From Iran to the US, crowding in emergency departments (EDs) can be observed on a global scale, if we look at the origins of articles regarding crowding problems and measures in this table from a systematic review of crowding [1].

An emergency department, short ED, refers to a department of a hospital, responsible for immediate care for unscheduled patients arriving at the hospital. It provides medical and surgical care and is staffed 24 hours a day, every day. A ED is mostly staffed with nurses and physicians[[2],[3]].

With an over all increasing number of patients searching medical attention [4] and increasing severeness of said cases added to an increasingly older population, which makes up a significant percentage of patients in EDs [5], crowding could just worsen in the future.

To understand the problem of crowding, we have to take a look at the processes in a ED to find out where problems can occur. For that, some background knowledge is needed, starting off with the process of ...

1.2 Triage

Triage refers to the process of examining people for injuries or sickness. This is made to treat patients with the most serious conditions first. In the process, the nurse would determine the acuity level depending on the individual's vital signs and description of its symptoms and medical history [6].

There exist several triage systems in the world, with the biggest difference in their depth of grading levels. Some systems just reach to three levels where some reach up to five which adds level 4 (less urgent) and level 5 (non urgent) into consideration. Three level triage systems have been validated and can be used for triage [7], as well as five level systems [8].

Here are two main triage systems in germany [8], the first one would be the Emergency Severity Index (ESI) and the second won the Manchester Triage System (MTS) [[9],[10],[11]]. In this case they are fully displayed in their five stages. They differ in the form in which they define the categories of acuity for patients and their requirement. But both have a linear ranking system from lowest to highest acuity.

The ESI triage system provides a ranking of 5 levels of acuity, ranging

from ESI 1 - red (highest acuity), ESI 2 - Orange, ESI 3 - yellow, ESI 4 - green and ESI 5 - blue. The triage process starts with examining if patients are in life danger and need lifesaving interventions. If yes, they will be put into the ESI 1 category, if not it will be assessed if they are at a high risk situation, if they are confused, lethargic or have severe pain. If yes, they will be put into the ESI 2 category, if not, they will be categorized by the resources their treatment would need (no resources - ESI 5, one resource - ESI 4, Many - ESI 3). It is possible, if vital data suggests so, to move patients from ESI 3 to ESI 2 [11].

MTS provides a ranking of 5 levels of acuity, but with the difference that it has additional information for the maximum amount of time until medical assessment. Additionally, the questionnaire for categorizing is different, it has questions for each acuity level and doesn't take the needed resources of treatment into account like ESI. The questionnaire starts with the most threatening symptoms like endangered respiration system, missing pulse or unconscious child for the highest acuity level (red), all the way to overheating and low levels of pain for the least acute level (blue). The levels of MTS start from red (highest acuity) with 0 minutes timespan till assessment, orange with 10 minutes, yellow with 30 minutes, green with 90 minutes and at last blue with 120 minutes max [[9],[10]].

Treatment will focus on the higher levels of acuity, therefore patients arriving later, but with any higher Level may get treated first. It is very important to spot severe injuries early on and therefore reduce the chance of mortality and disability in patients [[12],[13]].

1.3 Process of emergency care

A typical process for patients going to an emergency department would start by arriving there, by themselves or by an ambulance.

After arriving at the ED, patients would wait at a counter and begin the triage process guided by a nurse.

After that, patients wait for treatment or further assessment in a waiting room. When being called, they would go to a free ED treatment bay and begin the registration process, by consenting to the treatment and collecting of information about them and their medical history by the ED staff [12].

With that done, their treatment can start. It will be conducted and overseen by an attending physician. It may be necessary to take samples via x-ray or blood and urine to better assess patients medical condition. This can lead to further waiting time mostly taking up to one or several hours and, in some cases, even more.

After analyzing their samples, the ED staff starts the reevaluation phase where an ED physician reevaluates patients conditions and determines if they can be sent home, be treated or be admitted to a hospital bed. Lastly, follows the discharge where patients would get information on home-treatment, medication or follow-up medical care to improve their short term outcome [12]. There are many steps where the delay of one process can negatively influence patients treatment in general and it's result.

In the next step, we will explore crowding as a symptom caused by problems in the emergency treatment process. For that we first need a ...

2 Current view on crowding

You can see crowding in its simplest form in EDs, where needs for emergency services exceed the available resources for patient care in EDs, therefore not being able to take care of patients in a recommended time frame[14].

ED Crowding can indicate a problem related to an imbalance in supply and demand. This can be seen in overflowing medical facilities, which results in diminished patient-health outcomes [15]. In addition to that, treatment outside dedicated medical areas like hallways, treatment through an ED nurse and not an actual doctor and an increased ambulance diversion time can lead to reduced satisfaction in patients and staff, reduced patients' safety, worse quality of care and increased mortality [16].

After understanding what crowding is and how it occurs, we need to look at what defines crowding more precise and maybe how to quantify it, for example through measures and outcomes.

2.1 Definition

Now we have a understanding of crowding in its rudimentary form. But this rudimentary results in the existence of multiple definitions for crowding, with also different approaches [[1],[17],[[18],[19],[14],[16],[20],[21],[22],[23]].

First, there are definitions stating, crowding is a phenomenon that occurs when the ability of physicians and nurses to treat patients in a timely fashion is lower than demanded and thereby reflecting the health care system's efficiency and its not strictly related to measures like ED volume [17]. The main contributing factor would be admitted patients waiting in the ED and not a high count of low-acuity patients.

Other definitions like NEDOCS try to define crowding by a score to display if and how severe the crowding situation is. Here some attributes that previously have been not considered for crowding, like ED volume, the NE-DOCS score on the other hand uses the amount of patients to calculate crowding [[18],[19]]. This score is also somewhat controversial when looking at works trying to validate the score, where at one hand the precision of the measure is mentioned and on the other hand general doubts that the score really measures crowding in the first place [[20],[21]].

Another attempt is the emergency department work index (EDWIN) score [22]. It contains the number of patients in an ED, the triage category, the number of physicians on duty, the number of treatment bays and the number of admitted patients in the ED.

Additionally, there is a group of definitions taking other definitions into account to try drawing a more precise image of crowding like combining the occupancy rate with the EDWIN score or taking many more into account like ED volume, ED LOS, ED occupancy, boarding time, number of boarders, waiting room number, EDWIN and NEDOCS score [[1],[23]].

2.1.1 The Input-Throughput-Output model

Because it is not clear which measures in which constellation displays crowding best, it is difficult to form one unified definition. With this problem in mind, there is a framework taking this problem into account. It is split in three main parts: input, throughput and output [[24],[1]]. The model consists of many unidimensional measures, which haven't been combined to calculate a quantifiable value for the appearance of crowding, but can be grouped and categorized to make working with them possible. Measures that can be used in this framework are Left without being seen (LWBS) rates, mean ED LOS, number of ED boarders and ED boarding time, ambulance diversion occurrence, ED acuity (including total census, admission rate, total number of admissions, and proportion of non-urgent patients), ED boarding time, ED occupancy, length of stay over 6 hours and ED patient volume. But the framework is adjustable for other measures that have not been stated or even discovered yet. The framework splits the occurrence of crowding into three separate parts, where Input refers to the volume of patients arriving by themselves or by ambulance, throughput refers to the over all-time to treat or process patients and the output refers to patients leaving the ED, be it going home or boarding to a hospital bed. Any changes involving a rise in input, a delay in throughput, or a decrease in output can lead to crowding [24].

Now with several definitions for crowding, we need definitions for measures as well and collect the measures we want to focus on.

2.2 Measures for crowding

First up is ED occupancy. It is a percentage referring to the proportion of occupied beds in contrast to all available beds in an emergency department [1]. The second measure would be ED length of stay (ED LOS), which is the time a patient spends in the emergency department, beginning with the patients' arrival all until the patient leaves the emergency department. Similarly, ED volume accounts for the total amount of patients in an emergency department, at a specific time. These are the most mentioned measures in the external review [1]. The next three measures are connected to each other, beginning with the waiting room number, which is a score that displays the amount of patients, present in the waiting room of an emergency department [1]. Similarly, the number of boarders represents the number of patients waiting in the emergency department for an admission to a hospital (inpatient-) bed. Lastly, there is the ED boarding time for tracking the time, admitted patients wait in the ED to be transferred and moved to their hospital bed [1].

Other, a less often referenced measure is ambulance diversion, which can occur when an ED is fully occupied or overcrowded, and patients have to be redirected to another EDs, increasing the time until treatment [[25],[12]].

Finally, there are two scores who define crowding as a product of several measures resulting in a score that represents the business of an ED. Crowding is seen as a state that occurs one step after a busy ED [26]. The first score would be the National Emergency Department Overcrowding Scale (NEDOCS), which is a score calculated by the number of ED patients, the number of beds in the emergency department, the number of hospital beds, the number of hospital beds, the number of ventilators in the ED in use, the waiting time for the longest admission (for inpatient beds or tertiary medical care), the time when the last patient from the waiting room was called to a ED bed, the number of admits in the ED. The score here can range between 0 to 200, where 0-20 categorizes the ED as "not busy", 21-60 as "busy", 61-100 as "extremely busi but not overcrowded", 101-140 as "overcrowded", 141-180 as "severely overcrowded" and 181-200 as "dangerously overcrowded" [[26],[27]]. The second score is the Emergency Department Work Index (EDWIN). This score is calculated by the amount of patients in a specific triage category in addition to the triage category itself, the number of attending physicians, the number of treatment bays and the number of admitted patients in the Emergency Department. Its levels range from ;1.5 as "active but manageable", 1.5-2 as "buisy" and ¿2 as "overcrowded" [26].

After we have definitions of measures, we will have to define ...

2.3 Outcomes of crowding

The First outcome would then be the mortality of patients. Hospital mortality refers to the mortality rate of patients dying in the hospital and short term mortality to the rate of mortality shortly (for ex. one week) after discharge of the hospital. Mortality can be split into multiple parts, important for now would be hospital mortality and short term mortality [28].

Secondly would be the perception of care, which describes the subjective view on the state of Emergency Department crowding from the viewpoint of the staff, especially physicians and nurses [1].

At the end comes quality of care, which consists of many attributes from the efficiency of resource usage and effectiveness of health care, the administration of appropriate tests in a timely fashion and the administration of appropriate medication in a timely fashion (timeliness of care), avoiding negative through-put events like Leave-Without-Treatment (LWOT) and the avoidance of ambulance diversion [29].

This results in 8 measurements and 3 outcomes defined. The measures being the well-defined ED occupancy, ED length of stay, ED volume, the more heterogeneous waiting room number, number of boarders and the ED boarding time and the EDWIN and NEDOCS scores that have to be calculated. The three outcomes are mortality, quality of care and perception of care [1].

3 Discussion

First up, measurements like ED LOS, ED occupancy and ED volume are well studied, easy to understand, measure and communicate and are intuitively the most obvious and important measures for defining ED crowding [[1],[20]-[30]]. The other measures, like boarding time and boarding volume, are not as well studied, in contrast [1]. Likewise, the NEDOCS and EDWIN scores tend to be very complex in their calculation and have to be updated regularly (even though through computers and electronic medical records this process can be simplified) and as a result, are difficult to communicate to providers and administrators outside this topic [1].

On the other hand, in the case of boarding time and number of boarders, these measurements highlight another problem. Even though there is some variability in the definitions of measures, those specific two are especially fluctuating and it makes them the two most heterogeneous out of all crowding-defining measurements. That makes them the highest priority in the field of standardizing definitions, especially when boarding in general is a topic connected to patient dissatisfaction and mortality in some cases [30].

In the same way, between all studies reviewed, mortality was an outcome, well less studied than quality of care. Measures like the EDWIN and NE-DOCS scores did not even include mortality in their calculations. Therefore, if you are speaking about mortality, it would be safer to use the connection to the ED occupancy that is better studied than most other measures.

However, the lowest outcome studied is, by far, perception of care. Perception of care refers to the perspective of the staff on the workload and efficiency of the medical facility. While it is connected to every measure studied, unlike mortality, it has the least mentions in studies over all [1]. It is difficult to study because of its subjective nature. Generally speaking, Perception of care gives a feeling about the work flow and workload of a medical facility from their perspective. Therefore, it could give insight to the effectiveness of ancillary services (services required to support/supply the treatment of patients), surges in patient volume, the acuity of patients and the engagement of providers. On the other hand, it could be an indicator for staff (especially physician and nurse) burnout [[31],[32],[1]].

As mentioned before, the studies were mostly describing a direct connection between measures and outcomes. You can see that even clearer in the analysis of the review [1]. That makes it hard to form a general rule for crowding if the interaction between a variety of measurement groups isn't researched. In addition, some measurements are dependent on other factors, like boarding in general depends on patients being admitted to hospital beds, so when using boarding you have to know that it only takes this group of patients into considering. A possible way to still use boarding may be splitting the phenomenon of crowding into many branches, focusing on independent cases.

Some measures have heterogeneous definitions [1]. This puts up the question, how reliable the measures are if we don't have a clear definition of them. As a result, these measures should be avoided when possible and when it is not possible, then to use one existing definition and only use their data exclusively. This is connected to a lot of research and processing, so it should be a last option.

Then there is the fact that all definitions at hand are retrospectively formed by the studies externally gathered, which were not necessarily aimed at studying crowding itself [1]. So it is possible that some measures or less likely outcomes were not accounted for. To stay in the example of boarding measures, we stated that only patients admitted to hospital beds fall into this category, but when looking at the input-throughput-output model, that is just a part of the output. In this situation where definitions are unclear and connections as well, we should try to take all possible variables into account, thereby reducing the possibility to overlook certain measures. In this case, a measure for patients leaving without seen, leaving after treatment and leaving without treatment should be considered.

Generally speaking, the focus on the throughput of the model could be problematic. Aspects of crowding outside the ED area can easily be overlooked. It makes sense to focus on the throughput, because it makes it possible to measure crowding at a specific moment, but I think it would be advantageous to take the in- and output more into account. With that, we could better assess the state of crowding outside the moment right now. It could help with predicting crowding or searching for reasons why crowding occurred at one time.

3.1 Limitations

A problem with finding an absolute measure and definition for ED crowding lies in the measurements themselves. Those differ in aspects like the depth in which they have been studied (looking at the quantity of studies for each measure), the addressed outcomes (each study for a measure connects it to different outcomes) and the homogeneity of their definition regarding measures and outcomes [1].

Secondly, there are problems that make it impossible to form a generalization for countries and their populations and medical facilities caused by the origin countries and facilities the studies were conducted in. Most of them were conducted in US tertiary care hospitals and cannot be mapped directly onto other medical facilities around the world [1].

Looking further into the circumstances of the studies that formed this understanding of crowding measures correlating to crowding outcomes, it showed a problem that could lead to some deviation. In fact, all the cohorts and tables formed, which were used to group and compare measures and outcomes, were put together retrospectively without regarding the initial intent of each manuscript [[1],[19],[33]]. That leads to holes in the data that are maybe not covered because no study was intending to study ED crowding specifically in the first place. For example, no study captured the start of ED crowding from an optimal running emergency department to its volume getting higher until crowding occurs, so there is no hint at when and at what intensity crowding will take place [26].

In addition to that, the in-through and output Framework consists of multiple uni-dimensional measures and has been validated separately [34]. But for a multidimensional phenomenon like crowding, these separate measures may not be enough to fully display reality [24], which can make it hard to define a standardized measure for crowding [1]. Because of the fractured nature of crowding metrics, measures cannot be simply compared to one another, to form a uniform result.

Now going to my own observations regarding the limitations of the task of defining a metric for crowding, starting off with the problem mentioned in the section above. What I mean is the focus on throughput measures and the general occurrence of holes in the metrics, that won't allow it to fully display the ED processes and states in a full range. Thereby maybe lead to unrecognized factors important for defining crowding.

Then there is the problem of no clear lines in regard to measure definitions and how they are connected to the outcomes.

3.2 Results of Limitations

Concluding all limitations for the final discussion, the results are damping. The measures are not equal in their weight and depth, and there cannot be "one" defining measure to define ED crowding. At the moment, it is advisable to consider at least one measure that is thoroughly researched, like ED occupancy, ED LOS or ED volume. In addition, certain properties should be part of the validation and ranking process of each measure to get the ideal measure for a case.

First would be the degree and depth of a study, here depending on the number of studies conducted. After that the homogeneity of definitions, looking at the structure, important aspects and priorities written in it. Together with the ease of explaining a measure and understandable it is for out-standers and the complexity of calculating and measuring values to use for the study, these would be the constraints that could help to sort studies for further progress.

To improve the gray areas in this review, further research directly pointed at the ED crowding phenomenon and the aspects like measures not validated yet or taken into account, would be important.

So while forming a definition for crowding, it is important to put the existing constraints into context. The constraints would be that most likely no single definition can be made for crowding, the measures are not equal in depth, homogeneity and others mentioned in the results of limitation. Depending on the context, the requirements for crowding will change and to adapt to these changes, reevaluating crowding-defining measures with the context in mind, will be necessary. The reevaluation process should consider the depth to which a measure is researched, the heterogeneity of the definition, how easy it is to understand and teach the measure is. It is recommended to use multiple measures, and at least one of them should be an easy to understand and thoroughly researched.

4 Conclusion

This review highlights the complexity and blurry state of knowledge and lack of research of the topic itself. But in the progress we came up with an idea of what crowding is and why it is important to redirect further research into this area. Additionally, we may didn't get a direct definition for crowding, but we have a way to integrate it into our works in a way, that the mentioned limitations are considered and the best possible solution for a specific crowding problem can be made.

For future research, that means that it could be possible to check if data

sources can display ED crowding reliably and which aspect of crowding they display.

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