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VARIABILITY AND OVERCROWDING MANAGEMENT: ONGOING CHALLENGE FOR SPANISH HOSPITAL EMERGENCY DEPARTMENTS

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ABSTRACT

Background: ED overcrowding has become a common situation with significant negative effects on the quality of care. The aim of this study is to detail the flow of patients and their variability, and determine the existence of stable patterns that allow better planning of resources.

Methods: We performed a retrospective descriptive observational study of emergencies attended from 2008 to 2010 in the "Juan Ramón Jiménez" General Hospital (Huelva, Spain), with a sample of 343,233 visits. The time between consecutive arrivals of patients and the arrival patterns according to severity and clinical area were calculated using Microsoft Excel and Stat::Fit®. Quarterly differences were determined using the Kruskal-Wallis test.

Results: The mean value of the interarrival time, independently of the quarter ($p<.05$), was 2 - 4 minutes from 10:00 a.m. to 10 p.m. and 15-20 minutes from midnight to 8:00 a.m. The Priority (P) I Patients arrived every 119.05±136.71 minutes, the PII patients every 75.96±97.58 minutes, the PIII patients every 22.62±33.47 minutes and the PIV patients every 6.37±10.53 minutes. PIV had a fluctuating pattern. The arrival rate peaks at 1:00 p.m. on Monday in the Medical-Surgical area, at 10:00 p.m. on Monday for the Trauma area, and at 1:00 p.m. on Sunday for the Pediatric area.

Conclusion: The study shows that interarrival times and average arrival rates of patients have a defined and reproducible pattern for each level of severity and clinical area, which forces us to rethink the fixed capacity model and oriented towards flexibility of resources to reduce the overcrowding.

Keyword: Overcrowding, Hospital emergency department, Interarrival time, Demand variability, Capacity planning, Health management

INTRODUCTION

Emergency Departments (ED) overcrowding in developed countries (Acute Health Division 2001; Bagust et al. 1999; Committee on Pediatric Emergency Medicine 2004; Graff 1999; Schull et al. 2001; Shih et al. 1999) has become commonplace and has had major negative effects (Bernstein et al. 2009; Lynn 1991; Miró et al. 1999; Vidal et al. 2008). As the problem has worsened, different types of solutions have been adopted (García et al. 2008; Murillo et al. 2003; Sánchez et al. 2008; Sánchez et al. 2010) and although we are not starting from the same point as reported in the Spanish Ombudsman's Report in 1988 (Gil-Robles), the opinion is unanimous that the results were not as expected and that we are still almost at the same crossroads: the emergency healthcare chain in Spain is currently a chimera (Montero 2008) and it is not known how to put an end to the regular overcrowding in ED.

There are not just a few limited reasons for this overcrowding, rather, it is a symptom of a broad range of aspects that cannot be addressed alone by the ED or by hospitals with guaranteed success (Canadian Health Services Research Foundation 2010). In our opinion, the solution is inevitably a systemic focus on the whole emergency healthcare chain and its conceptualisation as a single functional entity (Herrera et al. 2011). While this is not yet a realistic option, the possible solution to this overcrowding may focus on three aspects (Litvak 2005):

1. Increasing the capacity, not only of the ED, but also of the hospital, as this may be one of the potential causes of the overcrowding.
2. Limit patient access with measures to reduce demand.
3. Adapt the amount of resources to the natural variability and eliminate artificial variability because of its impact on the overload and patient flow.

The first solution should only be adopted if the current capacity available is being correctly used and is insufficient to meet demand, as otherwise more resources would be

being added to an inefficient system, causing longer waiting lists. For example, it would be useless to add more consulting rooms to the emergency department in order to improve patient flow if bed management remained invariable.

As regards the second solution, we consider for example, that it would be an error to use co-payments —the Spanish National Health System is publicly funded and provides universal free health services— with the aim of generating more money for a highly inefficient model.

The solution, however, is not to incorporate more resources or limit demand, but rather to focus on variability, as established in the third alternative. This should be treated as a general concept that covers two categories (Litvak 2005):

a) External or Natural Variability

This may be caused both by patients and healthcare professionals and cannot be eliminated, although it can be managed. The reason for this is, on the one hand, that emergency department demand is random, heterogeneous in terms of patient profiles and cannot be planned, and on the other hand, that professionals with less experience and qualification may slow down patient flow.

b) Internal or Artificial Variability

This originates from poorly designed and inadequate processes. Unlike with the previous category, this variability must be identified and eliminated.

Due to the size of this subject, this study only focuses on variability caused by patient demand, given the impact that its lack of analysis has on overcrowding. The surprising fact is that many ED do not take this type of variability into consideration and normally schedule "average" resources. This results in daily inactivity in quiet periods and delays and overcrowding at peak times.

Furthermore, these services do not usually calculate the time between the arrival of two consecutive patients, in spite of being one of the most valuable indicators for managing variability caused by patient flow. As such, for example, knowing that 6 patients will arrive per hour is insufficient, since it is necessary to consider how often each patient will arrive. Therefore, a patient arriving every 10 minutes is not the same as six patients arriving at the same time. Both situations provide the same information about frequency (six patients per hour), but the second is more difficult to deal with from the point of view of resource planning and overload management.

As regards arguments that use randomness and heterogeneity of demand as elements that prevent proper planning, several studies (Higginson et al. 2011; Jones et al. 2006; Ong et al. 2009; Walley et al. 2006) have highlighted that there are very stable patterns, with well-defined peaks and troughs. However, the most surprising aspect is that these demand periods are highly similar regardless of geographical location (Figure 1) (Canadian Institute for Health Information 2005; Higginson et al. 2011; Ong et al. 2009; Walley et al. 2006). With this predicament in mind, this study seeks to achieve two objectives: 1) validate the existence of stable demand patterns in our ED, which are basic for reducing overload, and 2) know patient flow and its variability in detail with a view to adequate resource planning. This second objective will be achieved by analysing the arrival pattern, the severity of patients' condition and clinical areas involved, with the latter being an element that differentiates this study from others.

METHODS

A retrospective descriptive observational study was carried out on attended emergencies in the ED of "Juan Ramón Jiménez" General Hospital (Huelva, Spain). It is a teaching hospital that serves a population of 279,155 people (January 1st, 2010) out of a total population of 518,081 inhabitants, 22,523 admissions and 610 beds. Our sample

comprises all cases admitted to the ED (343,233 cases) from January 2008, when electronic medical record was established in the Andalusian Health Service, until December 2010.

The ED admits and classifies all emergencies and refers cases of tocogynecology and psychiatry to their respective departments. It has three work shifts (8:00 a.m. to 3:00 p.m., 3:00 p.m. to 10:00 p.m., and 10:00 p.m. to 8:00 a.m.) and patients follow a path designed according to their specific needs: Admission, Classification, Cardiopulmonary Resuscitation (CPR) area, Clinical areas (adult Medical and Surgical, Trauma and Pediatric), Waiting room, Observation Ward and support services. The severity and risk of patients are assessed using a classification protocol (*triage*), which is structured into four levels (Dirección General de Asistencia Sanitaria 2003): *(a)* priority I: imminent life threatening emergency, *(b)* priority II: instable emergency, *(c)* priority III: delayable or stable emergency, and *(d)* priority IV: less urgent.

The arrival time between two consecutive patients was calculated as the difference between the closure time of an inpatient admission, which is the first time recorded by the information system, and the closure time of the next inpatient admission.

In order to investigate patient arrival patterns, in both general terms and according to severity and clinical area, we performed a descriptive analysis of the quantitative (average and standard deviation) and qualitative (frequencies and percentages) variables using Microsoft Excel 2007 pivot tables.

We used the SPSS software version 19 to determine the possible quarterly differences in interarrival times and arrival patterns. Once we verified that the conditions of the one-way ANOVA were not met, we performed a Kruskal-Wallis test at the 0.05 level of significance.

RESULTS

The daily average and standard deviation of admitted emergencies was 314±12 with a rate of 41.02 visits per 100 inhabitants; our findings can be classified into two categories, previously stated in the objectives of this paper:

1. **Arrival time between two consecutive patients**

   We performed a Kruskal Wallis test to compare the hourly arrival rate per quarter for each day of the week (Monday $p = 0.484$; Tuesday $p = 0.622$; Wednesday $p = 0.360$; Thursday $p = 0.490$; Friday $p = 0.513$; Saturday $p = 0.465$; Sunday $p = 0.412$). The result of this test shows that the arrival rate to the ED follows a homogenous pattern from 7 am to midnight, regardless of the day of the week or the quarter of the year (see Figure 2).

   The busiest moments took place from 10:00 a.m. to 10:00 p.m., with an average of one patient entering the ED every 2 - 4 minutes. From midnight to 8:00 a.m. the time between patient arrivals increased from every 5 minutes to every 15-20 minutes, depending on the day of the week.

2. **Patient arrival patterns**

   2.1. *Average ED visit rates per hour*

   The average number of patient arrivals peaks at noon, clearly decreases at 3 p.m. and increases once again after that time, reaching a sustained high level during the afternoon shift.

   Patient arrival patterns are very similar throughout the week. (see Figure 3). The arrival rate starts to increase at 10:00 a.m. (10 patients/hour), it peaks at noon (20 patients/hour) and, after a slight decrease between 2 p.m. – 3 p.m., it remains steady throughout the afternoon. At midnight, the arrival rate slumps (less than 10 patients/hour), and it reaches a minimum of less than 5 patients/hour from 5:00 a.m. to 6:00 a.m.

2.2.*Analysis of average ED visit rates per hour according to priorities*

The majority of patients admitted to the ED, up to 70 per cent (221-232 patients/day) are level IV, 20 per cent (60-67 patients/day) are level III, 6 per cent (18-20 patients/day) are level II and 4 per cent (11-13 patients/day) are level I or emergencies. These percentages remain constant on a monthly basis. The rhythm of each priority case, expressed as the average and standard deviation of the ED visit rate per hour, is:

- Priority I every 119.05±136.71 minutes.
- Priority II every 75.96±97.58 minutes.
- Priority III every 22.62±33.47 minutes.
- Priority IV every 6.37±10.53 minutes.

Figure 4 shows the differences of ED visit rates per hour, according to priorities. However, the Kruskal-Wallis test (priority I $p = 0.420$; priority II $p = 0.705$; priority III $p = 0.832$; priority IV $p = 0.981$) concluded that the quarterly differences according to the level of priority are not significant. Low priority rates fluctuate more throughout the day than high priority rates. Serious emergencies (priorities I and II) are practically the same in the morning, afternoon and night, stable emergencies (priority III) show a higher fluctuation and deferrable and slight emergencies (priority IV) show the highest level of fluctuation.

2.3.*Analysis of average ED visit rates per hour according to clinical area*

The emergency cases attended in the ED can be broken down as follows: 51.9 per cent of cases (133 patients on average) were treated in Medical-Surgical consultation areas, 25.5 per cent (65 patients on average) in Trauma, 20.6 per cent (53 patients on average) in Pediatric and 2 per cent (5 patients on average) left the hospital before going through the entire health care process.

The graphical comparison between the average visit rate per hour of the ED as a whole and the different clinical areas shows that each clinical area has a different profile, with different peak times and days (see Figure 5). In the Medical-Surgical area, the arrival visit rate peaks on Mondays, at 1 p.m.; in the Trauma area the peak day is Monday, at 10 p.m., and in the Pediatric area, the arrival visit rate reaches the highest level on Sundays, at 1 p.m.

DISCUSSION

Our study shows that interarrival times and average arrival rates follow a defined and reproducible pattern on a quarterly basis, for the different levels of severity and clinical areas. These results confirm the conclusions of the Lean thinking for the NHS report (Jones et al. 2006) regarding health services demand.

These findings are particularly relevant when attempting to decrease excessive delays and large queues in the ED, since ED organization is mainly based on adapting capacity to demand variability, in both quantitative (flow) and qualitative (complexity and severity) terms, according to established times and quality standards. Along these lines, other national health systems have focused on treating the demand variability to prevent and manage ED chaos (Higginson et al. 2011; Jones et al. 2006; Ong et al. 2009; Walley et al 2006).

Previous studies in Spain have found that, although the flow of patients in the ED shows a high fluctuation, it is consistent with the behavioral patterns of the population (Peiró et al. 2010). Demand peaks on Mondays and it decreases during the weekends and public holidays, compared to work days or days when important social events are held. Arrival rate peaks at noon and it remains steady throughout the afternoon shift.

In addition, it has been proved that patients use the ED in the morning and in the afternoon, regardless of the accessibility or resources available in primary health care centers (Sánchez et al. 2005; Tomé et al. 2003; Tudela et al. 2003). This phenomenon has been happening for the last two decades; the majority of ED visits (56 per cent) take place from 8:00 a.m. to 5:00 p.m., which is the time slot that offers more services in the Spanish Health Care System (our findings are similar to the conclusions reported by other Spanish authors (Belzunegui et al. 1990; Ibáñez et al. 1991; Sánchez et al. 2005). This demand trend shows a behavior pattern in the Spanish society which is motivated by several reasons: the user's high perception of the quality of the ED, the ease at which the user can access to specialized health services in the ED, the users' perceived need for immediate medical attention, and the convenience of the system itself (Pasarín et al 2006; Sánchez et al. 2011).

Our study shows that ED visit rate peaks on Mondays, from 11:00 a.m. to noon. In addition, we conclude that the number of patients who use ED services is higher during the afternoon. Our findings are consistent with the conclusions reached in other countries, such as Britain (Higginson et al. 2011; Walley et al. 2006) or Canada (Canadian Institute for Health Information 2005), despite the fact that these countries have different cultural and health care habits. Therefore, we can conclude that the behavior pattern in Spain is not influenced by local factors.

The demand for health services in the ED shows additional special features: it must be prioritized according to the level of severity (PI to PIV), and it must be channeled to the appropriate clinical area (adult Medical-Surgical, Trauma and Pediatric). Sometimes, time constraints are essential. These special features must be considered when determining the best way to treat each ED case because, in addition to interarrival rates, it is necessary to know the distribution of patients according to levels of priority and clinical areas (Higginson et al. 2011).

In this sense, our study shows that the frequency of ED visits remains uniform on a monthly basis; each priority level has different interarrival time and visit rates, although automated triage is not available. When we analyze priorities according to the time of the day, we conclude that arrival rates of mild severe cases (PIV) are likely to be influenced by family, social, and work activities. This finding proves that our assumptions were correct: arrival rates in the ED are mainly related to low risk patients. This pattern of behavior has been observed in Canadian hospitals as well (Canadian Institute for Health Information 2005).

In addition, our study shows that the daily flow of patients and peak times are different in each clinical area. Therefore, and following Escarrabill's suggestion, capacity managers should take into account the specific demands of time and resources in each clinical area (Escarrabill et al. 2001).

One of the limitations of this study is that the first time recorded by the information system for each patient is the closing time of admission, not the starting time of admission. Since the administrative process is standardized, we assumed that the admission time shows no variability. Another limitation of this study was that all ED cases were from the same health care institution. Although this kind of data is similar among different healthcare institutions, there is a chance that there are some differences regarding clinical areas, classification systems, severity levels, distribution of the age pyramid, etc. Therefore, our findings may not be generalized to other health care institutions.

As a conclusion, we can state that the demand for hospital emergency services has a defined and reproducible pattern. Therefore, in order to improve the capacity planning, the demand needs to be properly managed. It is necessary to find the right balance between patients' needs and resources needed. If capacity planning is not properly managed, then ED will be overcrowded and will show low levels of efficiency.

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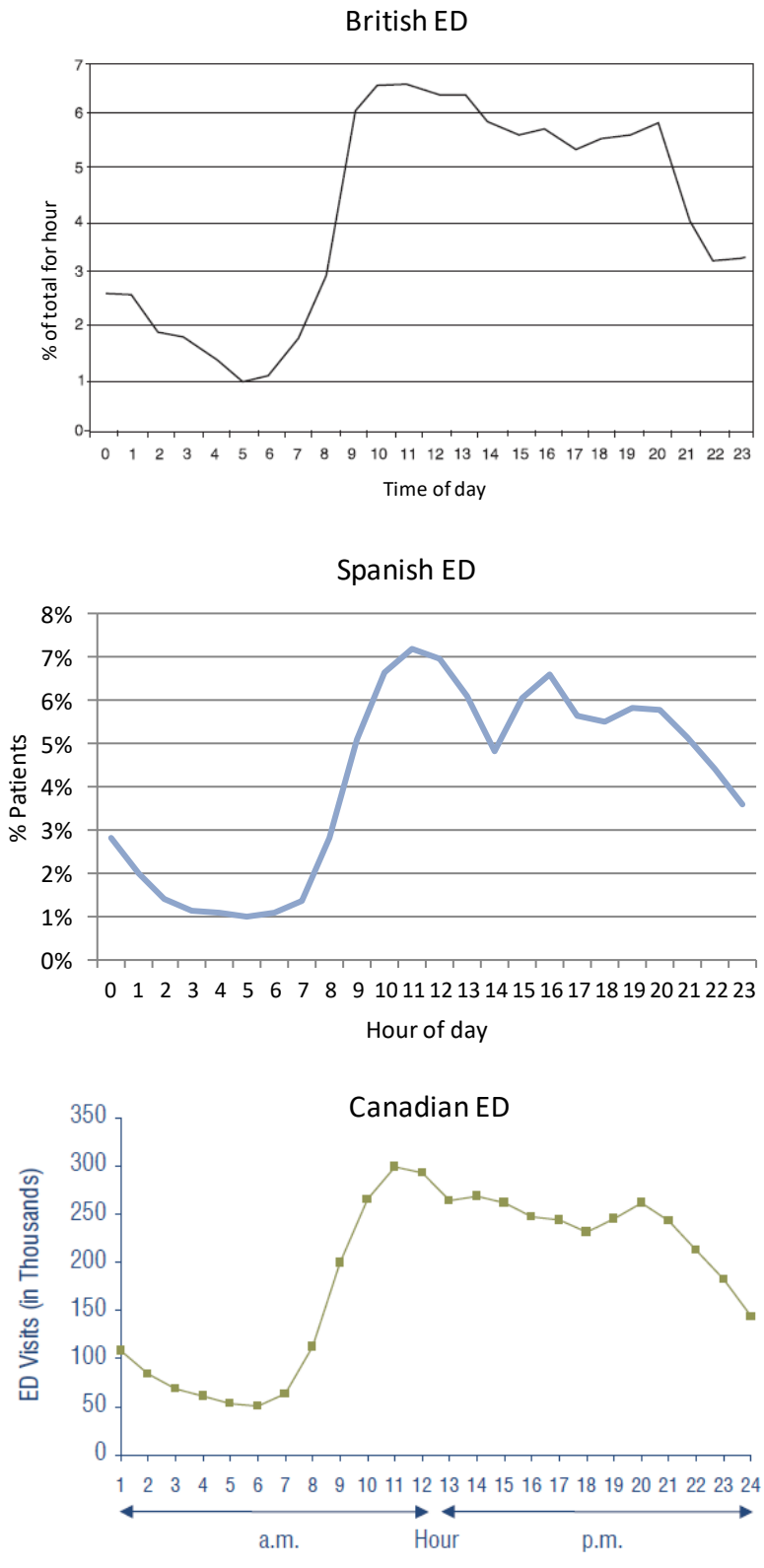

Figure 1. Similarity between daily arrival pattern of a typical British ED, the ED of Juan Ramón Jiménez Hospital in Huelva (Spain) and the ED in Ontario (Canada).

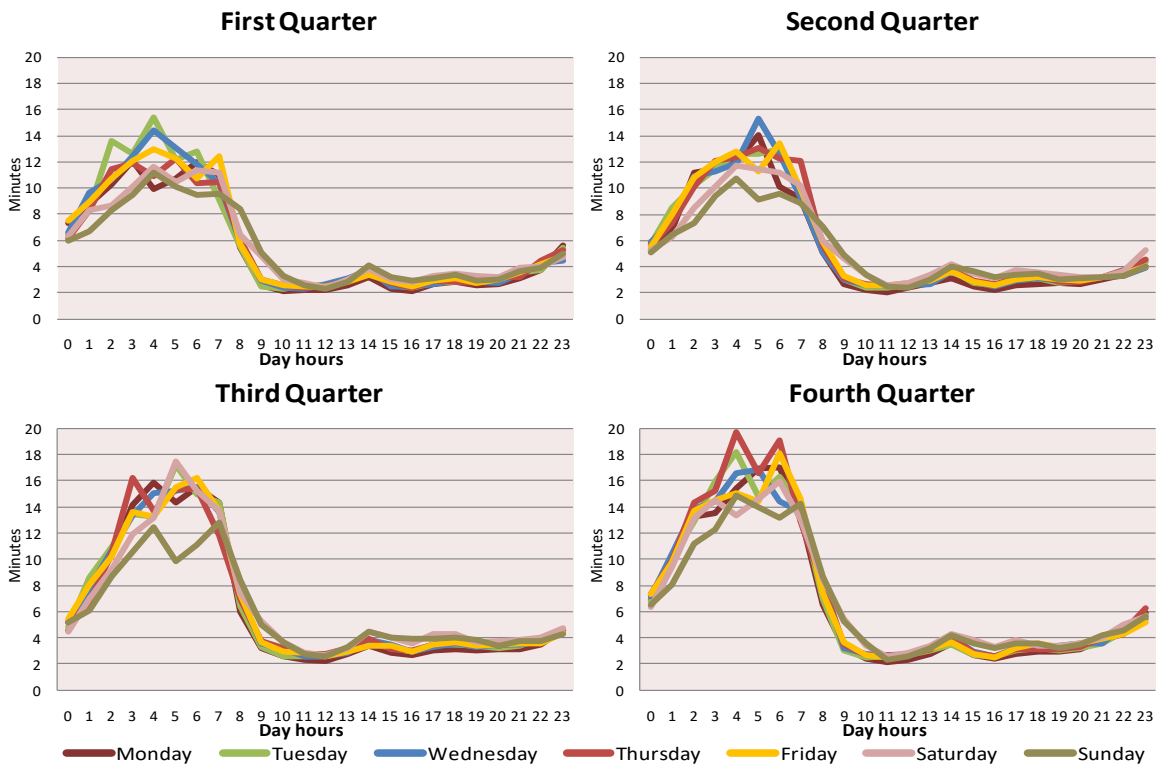

Figure 2. Average interarrival time in minutes per quarter

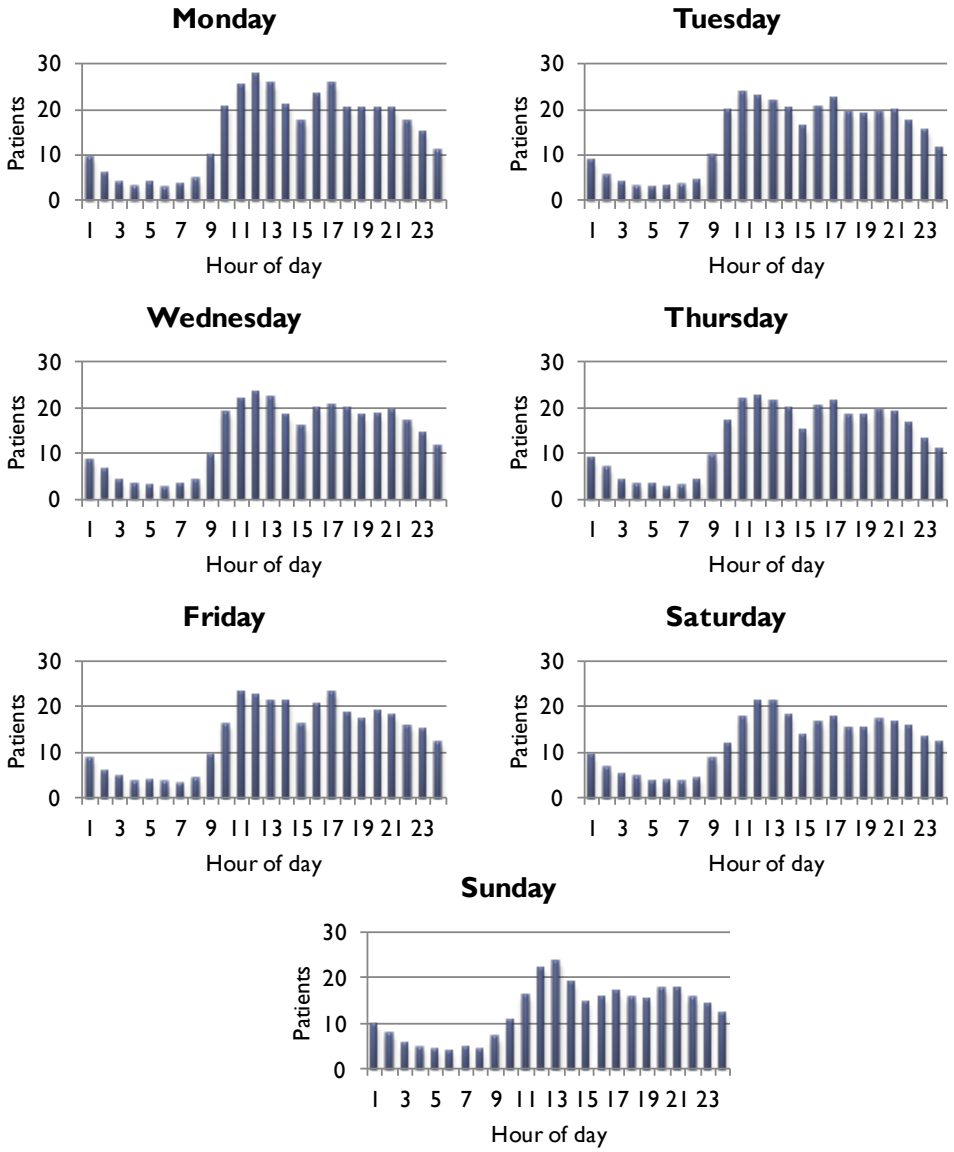

Figure 3. Average hourly ED visit rates according to day of the week

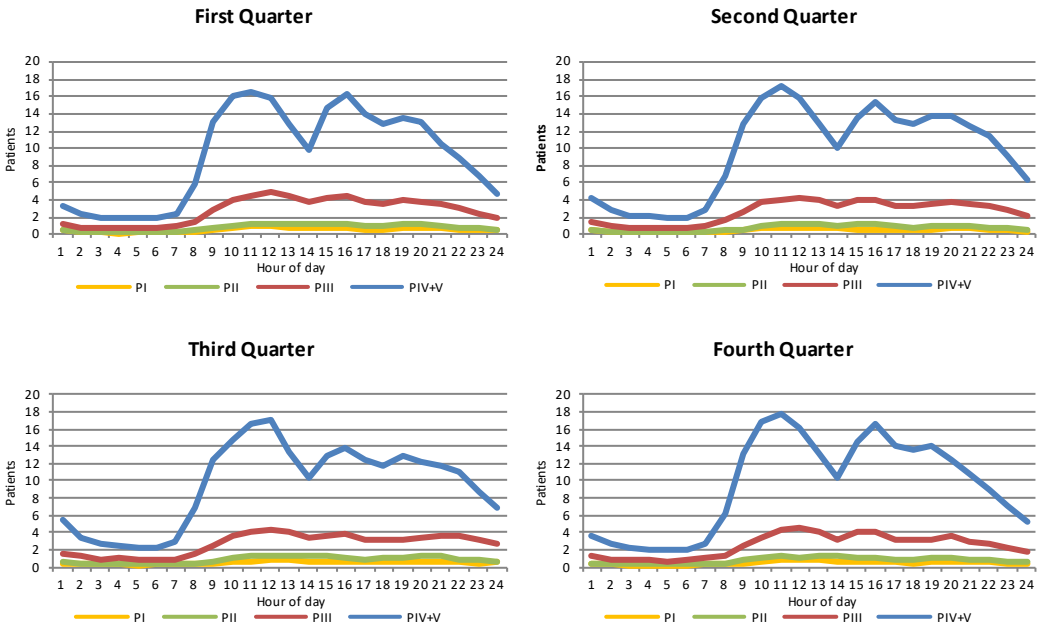

Figure 4. Average hourly ED visit rates according to priority

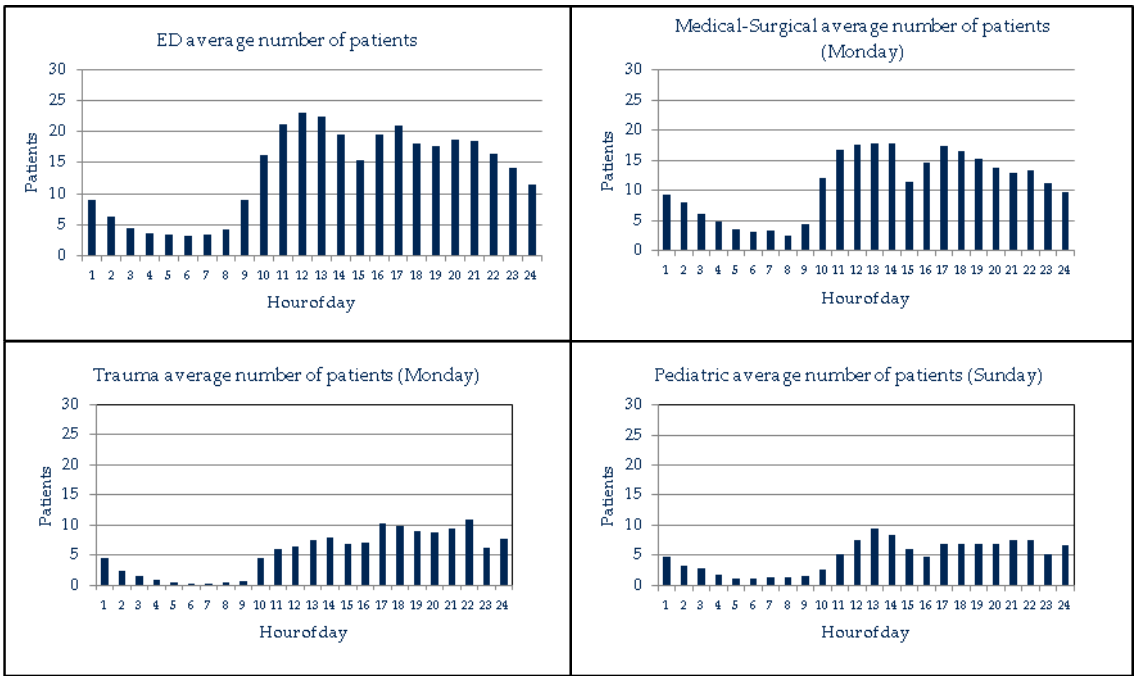

Figure 5. Comparison of global arrivals to the ED and arrivals at each clinical area and peak day