

Waiting times in emergency departments: a resource allocation or an efficiency issue?

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Abstract

Background: In recent years, the flow of patients to emergency departments (ED) in Western countries has steadily increased, generating overcrowding and extended waiting times. Scholars have identified four main causes for this phenomenon, related to continuity of primary care services; availability of specific clinical pathways for chronic patients; ED's personnel endowment; and organization of the ED. This study aims to provide a logical diagnostic framework to support managers in investigating specific solutions to be applied to their EDs to cope with high ED waiting times. The framework is based on the ED waiting times and ED admission rate matrix. It is applied to Tuscan EDs as illustrative example.

Methods: To provide the factors to be analysed once the EDs are positioned into the matrix, a list of issues is identified. The matrix is applied to Tuscan EDs. Data are collected from the Tuscan performance evaluation system, integrated with specific data on Tuscan EDs' personnel. The Tuscan ED matrix, descriptive statistics for each quadrant and Spearman's rank correlation analysis among waiting times, admission rates and a set of performance indicators were conducted to help managers to read the phenomena that they need to investigate.

Results: The combined reading of the correlations and waiting times–admission rates matrix shows that there are no optimal rules for all the EDs in managing admission rates and waiting times, but solutions have to be found considering mixed and personalized strategies.

Conclusions: The waiting times–admission rates matrix provides a tool able to support managers in detecting problems related to the management of ED services. In particular, using this matrix, healthcare managers can be facilitated in the identification of possible solutions for their specific situation.

Background

In recent years, the flow of patients to emergency departments (ED) in many Western countries has constantly increased [1]. This flow has often determined the ED overcrowding [2–6] that occurs every time the number of the waiting patients exceeds the available resources in terms of beds and/or personnel. Therefore, overcrowding is a phenomenon that seriously limits the hospital functions [7] in terms of both delays in patient care and poorer outcomes [8–11]. Overcrowding is also associated with the dissatisfaction of both physicians and nurses working under pressure and patients waiting to be treated [12]. In particular, waiting times are among the most important causes of ED patient dissatisfaction [8] and they negatively influence patients' perception of the service quality [13]. Complaints from dissatisfied patients are often vividly reported in the media, thus putting pressure on policymakers and hospital managers.

This trend seems irreversible, because it is based on the evolution of health expectations and the needs of populations. This has led a high number of scholars to focus on the factors affecting overcrowding and ED waiting time.

In particular, these factors can be grouped into four main categories: 1) how primary care and continuity are organized; 2) the existence and effectiveness of organizational models and clinical pathways for chronic patients; 3) the presence of bottlenecks related to the ED's personnel or equipment endowment; and 4) how the ED is organized and its connection with the rest of the hospital. The first two are related to admissions to the ED services, the other two to the way the ED and the hospital are organized to manage the flow of patients.

With reference to the first group of factors, how primary care and continuity are organized, some authors underline that overcrowding may depend on the high number of non-urgent patients seeking help from the ED [14–15], while these patients could turn to other health settings, namely primary care. There could be several reasons for the patient's choice, such as the capacity of the ED to provide a full, timely service, including diagnosis and examinations [16–17], as well as the higher perceived quality of ED services [18]. However, there are scholars outlining that admissions to the ED are higher when there are problems related to the supply side, in particular when primary care services fail to respond to patients' needs [17, 19–25].

The second group of factors influencing ED admissions is related to the existence and effectiveness of organizational models and clinical pathways for chronic patients. Indeed, since the beginning of 2000, disease management programmes have been proposed, like chronic care management [26–27], with the aim of improving the health conditions of patients [28, by identifying the health needs before the disease appears or it becomes serious. These programmes may be particularly relevant to cope with potential avoidable ED access, considering that chronic patients are frequent users (i.e. patients with at least four ED admissions per year) [29–33].

A third group of factors influencing waiting times in the ED is related to potential bottlenecks such as the ED structural endowment of physicians and nurses (and rooms). Some studies outline that waiting times may depend on an insufficient number of physicians and nurses [34–36] or equipment like the existence of diagnostic imaging reserved for the ED [37–38].

The last group of factors influencing ED overcrowding and waiting times concerns how the ED is organized and its integration with the rest of the hospital. For instance, the existence of fast tracking for specific health problems (such as pregnancy or eye issues) may reduce waiting times, because patients going to the ED for these conditions are taken care of directly by specialist clinics or wards, thus helping the ED personnel to cope with demand [37–38].

Another aspect related to organization is boarding that occurs when patients needing hospitalization have to wait in the ED because no ward beds are available [3, 35, 39–40]. This implies that the effort of ED personnel is, at least in part, diverted from the new patients that come to the ED because they have to pay attention to patients waiting to be hospitalized [41].

To support hospital managers in coping with the third and fourth groups of factors affecting ED waiting times, some scholars have proposed operation or lean management approaches [42–43], whilst to cope

with the first two groups of factors, many scholars [17, 19–25] suggest rearranging primary care or healthcare pathways. However, how to determine the factor(s) that may affect waiting times in a specific ED is an issue as yet uncovered in the literature. It is a topic often left in the hands of hospital managers, who have to analyse their own data. It may also be difficult because of the possible bias coming from the lack of comparisons (such as the definition of personnel endowment) or a lack of information at a system level (for instance hospital cannot have access to primary care efficiency or the effectiveness of healthcare pathways).

This study aims at providing a logical framework that both the meso-level of government (such as regional governments) and hospital managers can use as a diagnostic tool to understand ED's specific positioning with reference to the different factors possibly influencing ED waiting times, therefore supporting them to find the solutions that can suit their EDs. This diagnostic framework is applied to the Tuscan health system to illustrate how to read it.

Methods

The diagnostic framework to cope with ED waiting times

To provide a diagnostic logical framework to detect the specific situation and the factors influencing ED waiting times, we propose a descriptive study based on a matrix that compares ED waiting times with the ED admission rate. This framework has been designed and applied to other services [44, 45]. It is based on performance benchmarking. The position in the matrix, thanks to the graphical representation, allows us to rapidly realize if the waiting times or the ED admission rates are higher or lower than other EDs in the region. This approach may support regional and hospital managers in shortlisting the questions they have to answer to identify the potential strategies that the ED or the health system can take into account in order to manage waiting times better.

Positioning the EDs inside the four quadrants allows us to compile a list of potential factors affecting their performance (see Figure 1). Accordingly, specific hypotheses concerning the solution to the problems and the consequent strategies can be outlined.

The EDs in the upper left quadrant (high waiting times/low admission rate) show a good performance in terms of admission rates but some problems managing waiting times. Therefore, these EDs may primarily look at solutions inside their organization. In such circumstances, managers can investigate factors related to the abovementioned third and fourth groups of potential factors affecting high ED waiting times. In particular, the list of questions (not exhaustive) that hospital managers may deal with related to the ED's staff endowment, staff productivity and equipment availability. Other potential factors leading to higher waiting times can be related to the hospital's organization, such as the existence of fast-track pathways or the capacity of the wards to take in rapidly those patients who need to be hospitalized.

In the case of the upper right quadrant (high waiting times/high admission rate), the EDs show problems in relation to both the admission rate and waiting times. In these circumstances, the list of questions is

longer, because solutions may refer not only to the ED/hospital but also to the primary care. The managers could investigate a mix of issues related to all four groups of factors identified in the literature. Problems related to the high ED admission rate pertain to the overall organization and performance of the healthcare system, usually outside the ED's control. In particular, the factors in the first two groups refer to i) how primary care and continuity are organized; and ii) the existence and effectiveness of organizational models and clinical pathways for chronic patients. Another group of issues that may affect the situation of EDs positioned in that quadrant may concern the third and fourth groups: delays both in the admission phase (for instance, in terms of the presence of fast-track protocols) and in the discharge phase (due, for instance, to boarding for admission to wards); and bottlenecks concerning, for instance, diagnostic imaging services and structural efficiency (staff productivity and staff endowment).

The EDs in the bottom right quadrant (low waiting times/high admission rate) are efficient in terms of waiting times, but the situation may suggest a sub-optimal resource distribution among the care settings and a potentially inadequate response of primary care services to the health needs of the population.

Those EDs that are in the bottom left quadrant (low waiting times/low admission rate) are in an apparently good situation where demand (admission rate) and waiting times seem to be under control.

Study setting

This matrix was applied to Tuscan EDs' data to better highlight the support that this diagnostic framework can provide to managers and policymakers to cope with ED waiting times.

Tuscany is a medium-size Italian region with a population of 3.75 million and a good level of performance among its healthcare services [46]. However, there is wide variation in performance results among its districts and EDs. Consistent with the international trend, the number of admissions to Tuscan EDs increased by 5.4 per cent in the last seven years, standing at 1 million and half of all admissions. The service is provided by 38 EDs in three local health authorities and four teaching hospitals, grouped in 25 territorial districts.

In 2018, the overall admission rate to the ED per 1,000 inhabitants was 361.49, with great variation among the districts (from 279.99 to a maximum of 556.49) and among the ED admission rate related to non urgent codes, where the average was 88.28 per 1,000 inhabitants (from 43.59 to a maximum of 146.52). In terms of waiting times, the median waiting time was 72 minutes, from a minimum of 36 minutes to a maximum of 282 minutes. Urgent priority codes, which need immediate admission to treatment, are included.

Data collection

Apart from the EDs' waiting times and admission rates, most of the variables used to detect the factors affecting high EDs waiting times are based on the selection of indicators used by the Tuscany region to

assess the overall performance of its healthcare services [47]. In particular, for factors related to primary care and continuity, we investigated General Practitioner (GP) density; for factors related to the existence and effectiveness of chronic disease management programmes, we considered the indicators of avoidable hospitalizations and enrolment into the Tuscan chronic care programme monitored by the Tuscan performance evaluation system [48]; for factors related to the presence of bottlenecks, we used the indicators from a Tuscan research on ED personnel [36]; for factors related to EDs' performance and hospitals' organization, we considered all the indicators referring to the Tuscan performance evaluation system. These indicators cover both quality aspects (such as the number of ED readmissions) and the appropriateness (such as the percentage of hospitalized patients admitted to the ward within eight hours) [48].

Table 1 summarizes the indicators adopted to measure the four groups of factors and their measures.

Data concerning ED admission rates, waiting times and performance of primary care were retrieved from publicly disclosed data on the Tuscan performance evaluation system (<https://performance.santannapisa.it/>); data related to personnel come from a research report [36]. For data about the endowment of ED personnel, we used the last data available (2015). All other data are dated up to 2018.

To design the matrix, we linked ED admission rates, computed at the district level, and ED waiting times, computed at the hospital level. Therefore, as a methodological criterion, for those districts which comprise more than one hospital, we considered the waiting times at the dominant ED. The dominant EDs always represents more than 70 per cent of the overall admission per inhabitants.

The reference lines that divide the matrix into four quadrants represent the regional median values.

Data analysis

The analysis conducted is a qualitative description of the application of the diagnostic logical framework to the Tuscany data. We report some descriptive statistics for the four quadrants to illustrate how this matrix can help managers to understand their situation.

To complete the study, a correlation analysis among variables was performed with a 10 per cent level of significance. We executed the Spearman's rank correlation because most of the variables were not normally distributed. The correlation analysis may help to identify common patterns among the Tuscan EDs in relation to the factors analysed, suggesting that some issues may require regional intervention.

Results

Table 2 shows the Spearman's rank correlation matrix. It is worth noting that there is no significant association between ED waiting times and ED admission rate. Although a high level of ED admission rate

may lead to overcrowding, it seems that in Tuscany, other factors (or a mix of them) may cloud this relationship.

According to the findings of Table 2, some common patterns seem to characterize Tuscan EDs.

With reference to factors related to the first group, continuity of care, the number of GPs per inhabitant seems to be related to neither ED waiting times nor the ED admission rate. As regards the second group of factors, most of the indicators used as proxies to analyse chronic disease management programmes suggest that better performance in these programmes is related to lower ED waiting times.

Regarding the factors used to analyse the influence of potential bottlenecks, on the one hand, the number of ED Full Time Equivalen (FTE) per 10,000 admissions is negatively correlated with ED waiting times: EDs with lower FTE per 10,000 admissions show longer waiting times. On the other hand, the number of ED FTE per 10,000 admissions shows a moderately negative association with ED admissions: EDs with lower FTE per 10,000 admissions show higher ED admission rates. While the first association may suggest a potential resource allocation strategy at regional level, the second suggests that when ED admission rates are high, staff endowment may be not able to cope with the high demand in a timely manner.

Finally, the most represented group of factors is those related to the organization. There are several associations among the variables. In particular, higher occupancy rates are associated with higher ED waiting times, suggesting that collaboration among hospital wards and the ED is an issue that Tuscan EDs have to look at. This relationship is also found in other indicators looking at similar aspects such as prompt admission to the hospital ward. Some organizational structures, such as the observation unit, seem to help the ED cope with high waiting times. Other associations suggest that the more EDs are able to respond to non-urgent patients treated within four hours, the higher the ED admission rates, while the higher the percentage of ED patients hospitalized, the longer the ED waiting times (also related to the capacity of the hospital ward to board them) and the lower the ED admission rates.

Correlation analysis suggests some elements that seem to characterize Tuscan EDs. However, some elements need to be investigated further on a case-based basis. Hence, in order to help hospital and local health authority managers to disentangle which are the issues to be investigated in their situations, the ED waiting times and admission rate matrix may be used.

Figure 2 shows how the Tuscan EDs are positioned in the matrix, while Table 3 reports the descriptive statistics for each quadrant. Some distinctive traits for these four quadrants emerge from the matrix.

EDs belonging to the upper-left quadrant (high waiting times/low admission rate) are characterized by the highest number of GPs per 1,000 inhabitants but lower performance in the indicators of chronic care. This seems to suggest that the primary care is well structured in terms of number of GPs (the first group of factors), but it is not well organized to treat chronic patients (the second group of factors). Despite the lower ED admission rates among EDs in this quadrant, on average, it presents a slightly lower number of

FTE physicians per 10,000 admissions than the regional mean, which could be a reason behind the higher ED waiting times (the third group of factors). In addition, with reference to the organization (the fourth group of factors), these EDs show the highest percentage of hospitalized patients and the highest bed occupancy rate. Another interesting aspect that characterizes this group of EDs is the lower recourse to the observation unit. All these aspects could be among the main causes of boarding and delay in the discharge phase.

In the upper-right quadrant (high waiting times/high admission rate), EDs show a poor primary care structure, having the lowest rate of GPs per inhabitant (the first group of factors), but a good performance in chronic disease management (the second group of factors). Personnel endowment shows the lowest values of the ED's groups, which can be a reason for the high ED waiting times (the third group of factors). Factors related to the organization (the fourth group) show that the bed occupancy rate is average, but these EDs seem to wait longer than other EDs to hospitalize patients in the intensive care units and have fewer patients in observation units, though for a longer time. These organizational reasons may lead to higher waiting times.

The bottom right quadrant (low waiting times/high admission rates) comprises EDs with a primary care structure slightly better than the regional average and good performance of the chronic disease management, so that the high admission rates rely on other factors. The low waiting times are coherent with an average ED endowment of personnel. The bed occupancy rate is the lowest among the four quadrants. In addition, the observation unit is intensively used, above all for short stays: this could reduce pressure on the wards and contribute to the highest percentage of patients hospitalized within eight hours.

The bottom left quadrant (low waiting times/low admission rates) comprises EDs characterized by an adequate number of GPs per 1,000 inhabitants and good performance in primary care related to chronic disease management, which are coherent with a low admission rate. The low waiting times may also be explained by the highest endowment of ED personnel. Moreover, the organizational factors investigated here seem useful to reduce potential problems of boarding, such as the low bed occupancy rate and the highest percentage of access to the observation unit.

Discussion

The Spearman's rank correlation seems to suggest some common patterns among the Tuscan EDs, while analysis through the ED waiting times and ED admission rates matrix shows that there are more specific issues to investigate for each ED or group of EDs.

The ED is part of a service delivery system, and the diagnostic logical framework presented in Figure 1 seeks to help managers to identify the flaws and strengths of the overall system, and the mixed strategies the local or regional health system has to apply. Indeed, the matrix allows an integrated analysis that takes into account the main factors influencing waiting times and admission rates—for instance, the organization of EDs, ED personnel endowment and the performance of primary care.

The findings of the correlation analysis highlight that resource allocation strategies and resource efficiency choices are associated with ED waiting times. In particular, FTE personnel per admission is negatively associated with ED waiting times, thus suggesting that a regional (or meso) level of government may help to manage ED waiting times, promoting a more equitable allocation of FTE per admission. Another strategy that can be supported at the regional level is to reinforce the implementation of the chronic disease management programme, already in place in the Tuscany region. This is negatively associated with ED waiting times, so monitoring and promoting its implementation across the Tuscan districts can help manage waiting times. In addition, regional (or meso) managers and policymakers can promote protocols to suggest the organizational choices related to hospital resource allocation (such as the use of observational units—the higher it is, the lower the ED waiting times) or to resource efficiency (such as the bed occupancy rate—the higher it is, the longer the ED waiting times) that can help manage ED waiting times.

The findings of the analysis of the four quadrants of the matrix provide empirical examples of what was found in Van den Heede and Van de Voorde's [49] review: there is no golden rule to reduce ED waiting times or ED admission rates, and strategies that hospital and local managers may adopt have to be personalized. Indeed, in some cases, it seems that the organizational factor that may affect ED waiting times is the relationship with hospital wards, despite an average bed occupancy rate. In other cases, high ED waiting times seem to be related to the primary care structure or the low performance of chronic care management.

Conclusions

This paper adapted the waiting times–admission rate matrix already used in other services [44–45] to the ED context, using the illustrative example of Tuscan EDs. The matrix can work as a logical diagnostic tool to help managers analyse the situation of their EDs.

A strength of this study is the classification of the main factors that previous researchers have identified as main determinants of ED admission rates and waiting times into a logical framework that can support managers to address the questions that are primarily related to their situation, thus helping them to find the solution. Indeed, the matrix may help to shortlist the issues to focus on according to the ED's position among the quadrants.

In addition, this diagnostic logical framework attempts to lead local and regional managers to cope with ED waiting times using a systemic approach, not only looking at the hospital or ED organization, but considering other factors that may affect their situation.

This study has a number of limitations. Firstly, the analyses and results refer to the context of one region (Tuscany) in one country (Italy). However, the logical framework proposed in this study, along with the kind of analyses conducted and the types of variable considered, may be easily replicated in other contexts since they are derived from theory. The results may be different, but the approach to detect the situation of each group of EDs could be the same.

Secondly, the waiting times–admission rates matrix presented in this study works well and is a supportive source of information for policymakers only when there is the opportunity to compare the performances and data of EDs with primary care, continuity and hospital performances. Moreover, countries and regions may enrich their analyses including more indicators per group of factors.

Thirdly, the matrix was presented and discussed in a workshop with the head of the Eds, but it has not yet been used by policymakers and managers to detect the factors affecting ED waiting times.

Finally, it is worth highlighting that this study is purely descriptive, without any claim to derive causal inference from the analyses presented. The matrix developed and the correlation analysis provide a picture of the actual situation characterizing Tuscan EDs, and offer an interesting starting point to support healthcare managers and policymakers in their analyses and potential solutions to problems linked to high ED waiting times or inappropriate admission rates.

Abbreviations

ED: emergency department

FTE: full-time equivalent

GP: General Practitioner

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The author Milena Vainieri is an Associate Editor of this journal.

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Authors' contributions

MV and CP designed the study, LC analysed data and CP conducted the review of EDs' literature. All authors contributed to writing and interpreting the results. All authors read and approved the final manuscript.

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References

1. Berchet C. Emergency care services: trends, drivers and interventions to manage the demand. OECD Health Working Papers, No. 83. Paris: OECD Publishing; 2015.
2. Di Somma S, Paladino L, Vaughan L, Lalle I, Magrini L, Magnanti M. Overcrowding in emergency department: an international issue. *Intern Emerg Med*. 2015;10(2):171–5.
3. Richardson DB, Mountain D. Myths versus facts in emergency department overcrowding and hospital access block. *Med J Australia*. 2009;190(7):369–74.
4. Dickinson G. Emergency department overcrowding. *Can Med Assoc J*. 1989;140(3):270–1.
5. Andrulis DP, Kellermann A, Hintz EA, Hackman BB, Weslowski VB. Emergency departments and crowding in United States teaching hospitals. *Ann Emerg Med*. 1991;20(9):980–6.
6. Schneider SM, Gallery ME, Schafermeyer R, Zwemer FL. Emergency department crowding: a point in time. *Ann Emerg Med*. 2003;42(2):167–72.
7. American College of Emergency Physicians. Crowding. Policy Statement; January 2006.
8. Pines JM, Hollander JE. Emergency department crowding is associated with poor care for patients with severe pain. *Ann Emerg Med*. 2008;51(1):1–5.
9. Bernstein SL, Aronsky D, Duseja R, Epstein S, Handel D, Hwang U, et al. The effect of emergency department crowding on clinically oriented outcomes. *Acad Emerg Med*. 2009;16(1):1–10.
10. Sprivulis PC, Da Silva JA, Jacobs IG, Jelinek GA, Frazer AR. The association between hospital overcrowding and mortality among patients admitted via Western Australian emergency departments. *Med J Australia*. 2006;184(5):208–12.
11. Guttman A, Schull MJ, Vermeulen MJ, Stukel TA. Association between waiting times and short term mortality and hospital admission after departure from emergency department: population based cohort study from Ontario, Canada. *BMJ*. 2011;342:d2983.
12. Higginson I. Emergency department crowding. *Emerg Med J*. 2012;29(6):437–43.
13. Nuti S. La valutazione della performance in sanità. Bologna: Il Mulino; 2008.
14. Young GP, Wagner MB, Kellermann AL, Ellis J, Bouley D. Ambulatory visits to hospital emergency departments: patterns and reasons for use. *Jama*. 1996;276(6):460–5.

15. Uscher-Pines L, Pines J, Kellermann A, Gillen E, Mehrotra A. Emergency department visits for nonurgent conditions: systematic literature review. *Am J Manag Care*. 2013;19(1):47–59.
16. Marcacci L, Nuti S, Seghieri C. Migliorare la soddisfazione in Pronto Soccorso: metodi per definire le strategie di intervento in Toscana. *Mecosan*. 2010;74:3–18.
17. Coster JE, Turner JK, Bradbury D, Cantrell A. Why do people choose emergency and urgent care services? A rapid review utilizing a systematic literature search and narrative synthesis. *Acad Emerg Med*. 2017;24(9):1137–49.
18. Ragin DF, Hwang U, Cydulka RK, Holson D, Haley Jr LL, Richards CF, et al. Reasons for using the emergency department: results of the EMPATH Study. *Acad Emerg Med*. 2005;12(12):1158–66.
19. Chen BK, Cheng X, Bennett K, Hibbert J. Travel distances, socioeconomic characteristics, and health disparities in nonurgent and frequent use of hospital emergency departments in South Carolina: a population-based observational study. *BMC Health Serv Res*. 2015;15(1):203.
20. Sarver JH, Cydulka RK, Baker DW. Usual source of care and nonurgent emergency department use. *Acad Emerg Med*. 2002;9(9):916–923.
21. Cowling TE, Cecil EV, Soljak MA, Lee JT, Millett C, Majeed A, et al. Access to primary care and visits to emergency departments in England: a cross-sectional, population-based study. *PloS One*. 2013;8(6):
22. Cecil E, Bottle A, Cowling TE, Majeed A, Wolfe I, Saxena S. Primary care access, emergency department visits, and unplanned short hospitalizations in the UK. *Pediatrics*. 2016;137(2):e20151492.
23. Van den Berg MJ, Van Loenen T, Westert GP. Accessible and continuous primary care may help reduce rates of emergency department use. An international survey in 34 countries. *Fam Pract*. 2016;33(1):42–50.
24. Garthwaite C, Gross T, Notowidigdo M, Graves JA. Insurance expansion and hospital emergency department access: evidence from the Affordable Care Act. *Ann Intern Med*. 2017;166(3):172–9.
25. Fishman J, McLafferty S, Galanter W. Does spatial access to primary care affect emergency department utilization for nonemergent conditions? *Health Serv Res*. 2018;53(1):489–508.
26. Wagner EH, Davis C, Schaefer J, Von Korff M, Austin B. A survey of leading chronic disease management programs: are they consistent with the literature? *J Nurs Care Qual*. 2002;16(2):67–80.
27. Bodenheimer T, Wagner EH, Grumbach K. Improving primary care for patients with chronic illness. *Jama*. 2002;288(14):1775–9.
28. Coleman K, Austin BT, Brach C, Wagner EH. Evidence on the chronic care model in the new millennium. *Health Affair*. 2009;28(1):75–85.
29. Althaus F, Paroz S, Hugli O, Ghali WA, Daepfen JB, Peytremann-Bridevaux I, Bodenmann P. Effectiveness of interventions targeting frequent users of emergency departments: a systematic review. *Ann Emerg Med*. 2011;58(1):41–52.
30. Hoot NR, Aronsky D. Systematic review of emergency department crowding: causes, effects, and solutions. *Ann Emerg Med*. 2008, 52(2):126–36.

31. Pines JM, Asplin BR, Kaji AH, Lowe RA, Magid DJ, Raven M, et al. Frequent users of emergency department services: gaps in knowledge and a proposed research agenda. *Acad Emerg Med.* 2011;18(6):e64–9.
32. Bieler G, Paroz S, Faouzi M, Trueb L, Vaucher P, Althaus F, et al. Social and medical vulnerability factors of emergency department frequent users in a universal health insurance system. *Acad Emerg Med.* 2012;19(1):63–8.
33. Hudon C, Courteau J, Krieg C, Vanasse A. Factors associated with chronic frequent emergency department utilization in a population with diabetes living in metropolitan areas: a population-based retrospective cohort study. *BMC Health Serv Res.* 2017;17(1):525.
34. Lambe S, Washington DL, Fink A, Laouri M, Liu H, Fosse JS, et al. Waiting times in California's emergency departments. *Ann Emerg Med.* 2003;41(1):35–44.
35. Trzeciak S, Rivers EP. Emergency department overcrowding in the United States: an emerging threat to patient safety and public health. *Emerg Med J.* 2003;20(5):402–5.
36. Panero C, Nuti S, Marcacci L, Rosselli A. *Il quaderno del Pronto Soccorso.* Firenze: Polistampa Editore; 2016.
37. Cooke MW, Wilson S, Pearson S. The effect of a separate stream for minor injuries on accident and emergency department waiting times. *Emerg Med J.* 2002;19(1):28–30.
38. Sanchez, M, Smally AJ, Grant RJ, Jacobs LM. Effects of a fast-track area on emergency department performance. *J Emerg Med.* 2006;31(1):117–20.
39. Elder E, Johnston AN, Crilly J. Systematic review of three key strategies designed to improve patient flow through the emergency department. *Emerg Med Australas.* 2015;27(5):394–404.
40. Moskop JC, Sklar DP, Geiderman JM, Schears RM, Bookman KJ. Emergency department crowding, part 1—concept, causes, and moral consequences. *Ann Emerg Med.* 2009;53(5):605–11.
41. Derlet RW, Richards JR, Kravitz RL. Frequent overcrowding in US emergency departments. *Acad Emerg Med.* 2001;8(2):151–5.
42. Shi P, Chou MC, Dai JG, Ding D, Sim J. Models and insights for hospital inpatient operations: time-dependent ED boarding time. *Manage Sci.* 2016;62(1):1–28.
43. Improta G, Romano M, Di Cicco MV, Ferraro A, Borrelli A, Verdoliva C, et al. Lean thinking to improve emergency department throughput at AORN Cardarelli hospital. *BMC Health Serv Res.* 2018;18(1):914.
44. Nuti S, Vainieri M. Managing waiting times in diagnostic medical imaging. *BMJ Open.* 2012;2(6):e001255.
45. Lungu DA, Ruggieri TG, Nuti S. Decision making tools for managing waiting times and treatment rates in elective surgery. *BMC Health Serv Res.* 2019;19(1):369.
46. Nuti S, Vola F, Bonini A, Vainieri M. Making governance work in the health care sector: evidence from a 'natural experiment' in Italy. *Health Econ Policy L.* 2016;11(1):17–38.

- 47. Nuti S, Seghieri C, Vainieri M. Assessing the effectiveness of a performance evaluation system in the public health care sector: some novel evidence from the Tuscany region experience. *J Manag Govern.* 2013;17(1):59–69.
- 48. Faraoni M., La Mastra M., Profili F, Vainieri M. *Welfare e salute in Toscana.* 2019. ARS Toscana.
- 49. Van den Heede K, Van de Voorde C. Interventions to reduce emergency department utilisation: A review of reviews. *Health Policy.* 2016;120(12):1337–49.

Tables

Due to technical limitations, Tables 1-3 are provided in the Supplementary Files section.

Figures

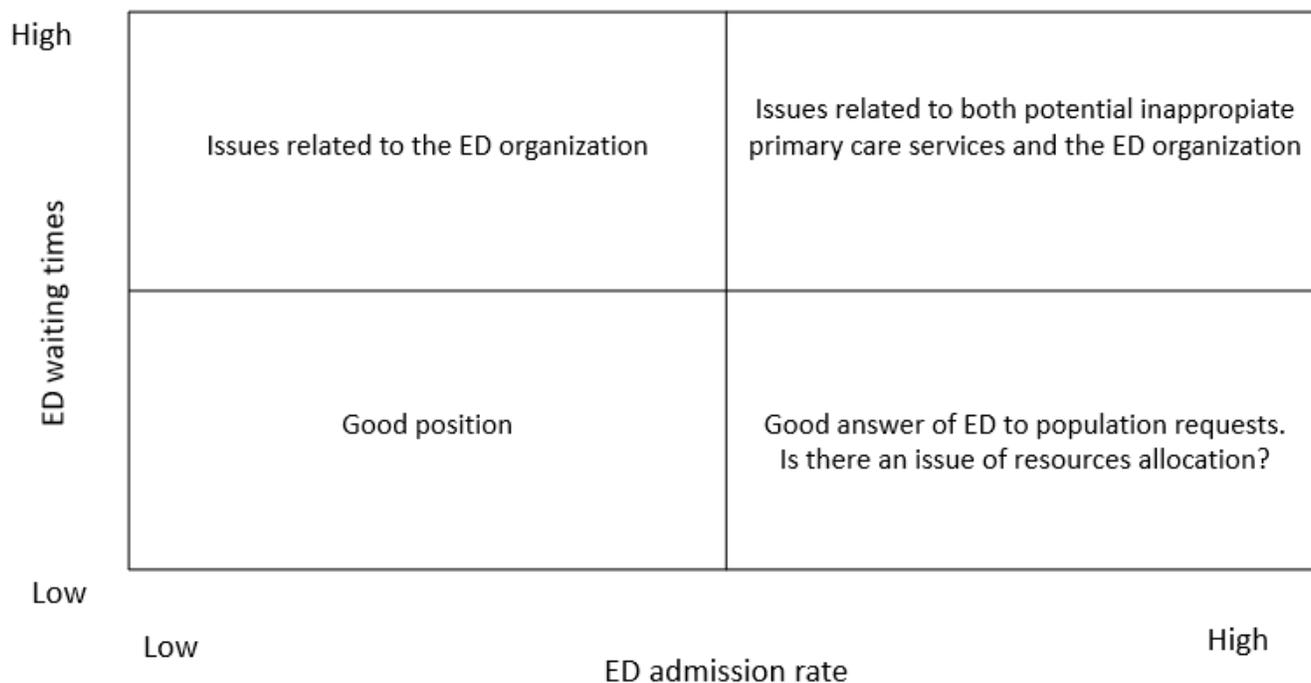


Figure 1

A scheme for the waiting times–admission rate matrix

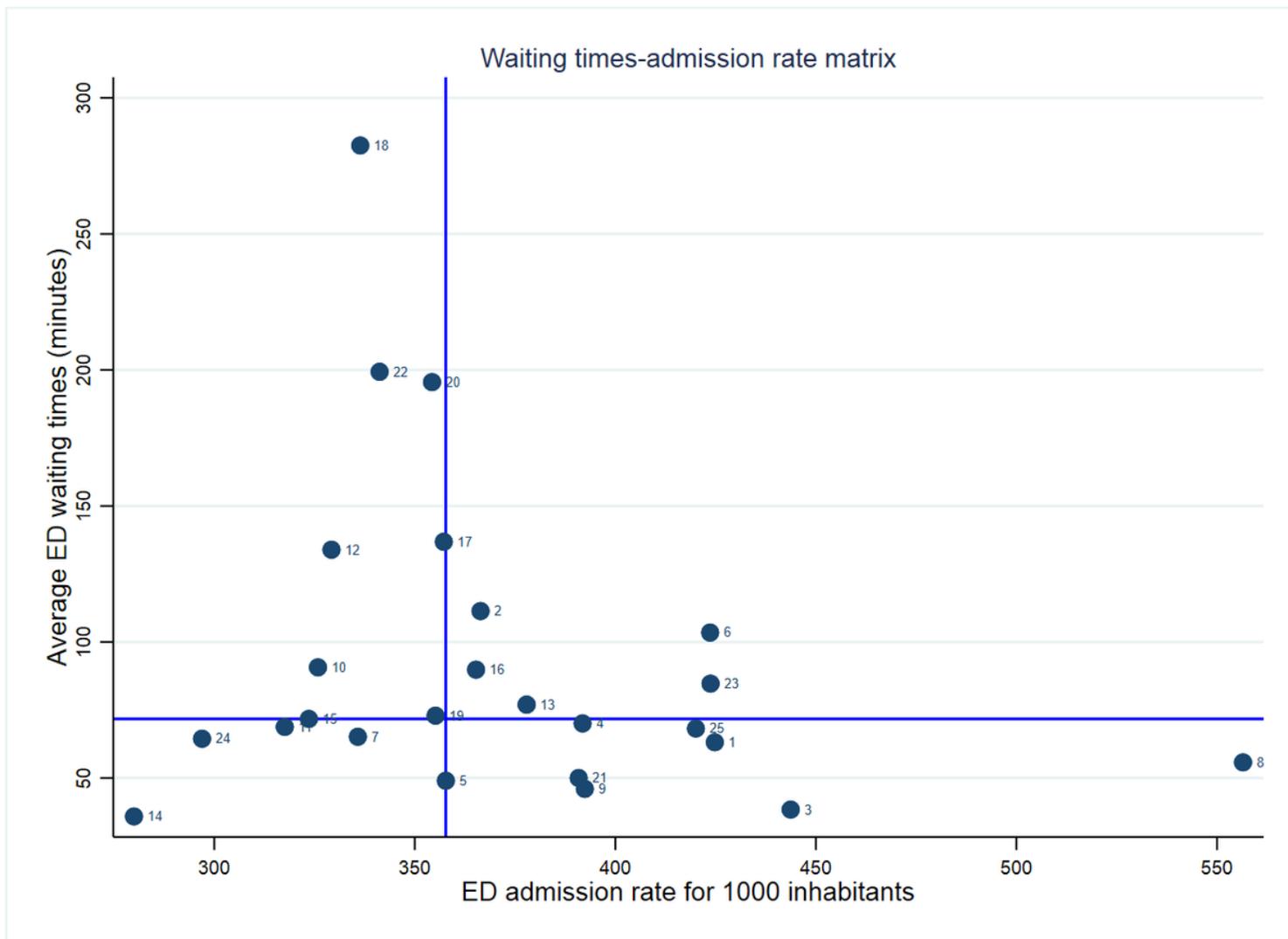


Figure 2

ED waiting times–admission rate matrix for all the Tuscan EDs

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table3ED.xlsx](#)
- [Table2ED.xlsx](#)
- [Table1ED.xlsx](#)