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ORIGINAL RESEARCH ARTICLE

Robustness and Effectiveness of the Triage System in the Pediatric Context

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Abstract

Background The increasing use of emergency departments (EDs) potentially compromises their effectiveness and quality. The evaluation of the performance of the triage code system in a pediatric context is important because waiting time affects the quality of care for acutely ill patients.

Objective In this study, we aimed to assess the effectiveness and robustness of the triage code system in a pediatric context and identify the determinants of waiting times for urgent and non-urgent patients.

Methods Data regarding 37,767 pediatric patients who accessed the ED of a major Italian pediatric hospital in 2015 were investigated in order to study patient numbers and waiting times. The determinants of waiting times for urgent and non-urgent patients, as well as variables referring to the "supply side," such as periods of staff shortage, were analyzed using a survival analysis framework.

Results For urgent patients, the waiting time between triage and the first physician assessment is generally below the standard threshold of 15 min and this is not affected by the number of non-urgent patients waiting for care. Conversely, the waiting time for non-urgent patients is affected by ED flow, periods of staff shortage, and non-clinical variables (age and nationality).

Conclusion Our results suggest that the triage level assignation system is effective in terms of safety for urgent patients. The current ED organization adequately fulfills its primary goal of providing healthcare for acutely ill patients.

Key Points for Decision Makers

Data indicate that for urgent patients, the waiting time between triage and the physicians' assessment is generally below the standard threshold of 15 min.

While the waiting time for non-urgent patients is affected by a number of demographic and contextual variables, the waiting time for urgent patients tends to be affected only by the presence of other urgent patients in the ED, and, secondarily, by age and means of arrival.

Our results suggest that the triage system can be considered robust in the presence of a high number of patients and staff shortages.

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1 Introduction

Over the last decades, the role of emergency departments (EDs) has evolved worldwide and EDs have become providers of not only acute emergency services but also of care for indigent patients, and, in general, of primary healthcare. As a result of this new role, there has been a considerable increase in the number of ED admissions and non-urgent patients (i.e., patients who bypass general practitioner services and frequently access EDs as a primary-care service) have become a relevant category of ED patients [1, 2].

The combination of increasing use of emergency services and insufficient availability of inpatient beds has led to an imbalance between ED capacity and the demand for emergency care, and there has been increased scrutiny of the issue of ED overcrowding [3].

Overcrowding is one of the major challenges in ED management and is often the main factor responsible for delays in diagnosis and treatment [4–6]. Sun et al. [7] concluded that in 187 Californian hospitals, ED overcrowding was responsible for 300 additional deaths, 6,200 additional days of hospitalization, and additional costs for adult admissions amounting to US$17 million. Input factors, namely patient volume and case mix, have long been considered the main factors responsible for overcrowding episodes [8]. However, recent literature suggests that non-emergency complaints are only one of the possible causes of overcrowding, and other output issues, specifically, the inability to transfer emergency patients to inpatient beds and the resulting prolonged stay in the ED of admitted patients, are the most relevant root causes of the problem [3, 9, 10].

In this challenging context, evaluating ED performance is a priority and the waiting time to physician assessment and treatment is a key indicator to be considered as it has a clear impact on patient safety [11]. The triage system is expected to guarantee an effective classification of patients according to clinical priority, distinguishing patients requiring emergency treatment from those requiring primary care. Different triage systems are used by EDs worldwide [12, 13], and clinical practices and guidelines may influence the effectiveness of triage systems [14–18]. A number of studies provide evidence that excessive ED flow is responsible for delays in the treatment of patients, including higher acuity patients. Gilboy et al. [19] demonstrated that during periods of ED overcrowding the adjusted median waiting times for urgent patients were significantly higher (increased by 3–35 %) than on non-crowded days. Acutely ill patients may also be motivated to leave the ED before receiving care to avoid unbearably long waiting times, resulting in an increased risk of adverse outcomes [20–23]. Kyriacou et al. [24] found a positive correlation between waiting times and "left-without-being-seen". Conversely, other studies have concluded that waiting times for urgent patients are not [25] or are only marginally [26] affected by the presence of low-complexity patients. Despite the extensive literature on the effectiveness of triage, there are limited studies specifically examining pediatric EDs [27–30]. However, this topic deserves specific attention because of issues in the classification of pediatric patients, which are different from those used to categorize adults. Firstly, the evaluation of children's health status is a particularly challenging task due to their limited ability to explain symptoms, particularly in preverbal patients, and the need to rely on the perceptions of parents [31]. Parents' inexperience, excessive anxiety, and poor knowledge of pediatric healthcare, particularly amongst foreigners, are often the reasons for inappropriate use of pediatric emergency services [32, 33]. Furthermore, the clinical reasons for ED access and the corresponding severity level differ substantially between pediatric and adult patients. In a pediatric context, the clinical impression is often not reliable and symptoms are variable [31].

In this study, we assessed the effectiveness and robustness of the triage system using data derived from an Italian pediatric ED located in the administrative region of Liguria (Emergency Department of Pediatric Hospital Gaslini—Genova, Italy). The triage system used in most regions of Italy comprises four severity levels, according to different colors: white = non-urgent (always inappropriate) attendance; green = non-urgent (and often inappropriate) attendance; yellow = urgent attendance; and red = highly urgent attendance. In order to be effective, a triage system should be able to guarantee an appropriate waiting time to physicians' assessment and treatment of patients with urgent triage codes (i.e., yellow or red). Furthermore, a triage system should be able to guarantee that the number of non-urgent patients (i.e., white and green levels) does not affect the waiting time of urgent patients. Gaslini hospital is the only pediatric hospital in the region; it provides pediatric healthcare services to the entire regional population and also attracts patients from outside regional and national borders. This context is important in terms of service supply: while adult patients can be transported to more than one point of care, which are not far from each other, only a single center providing highly specialized care is available to children. In order to evaluate the robustness and effectiveness of the triage code system, we constructed a statistical model to identify the determinants of waiting times for urgent and non-urgent patients and establish whether ED flow, staff shortage, or other non-clinic variables had an impact on waiting times (and on quality of care, as an increase in waiting time is responsible for a quality reduction) for acutely ill patients.

2 Data and Methods

During 2015, approximately 88,400 children (aged 0–14 years) accessed the 19 EDs located in Liguria (i.e., out of every 1,000 residents in Liguria aged under 14 years, 484 attended an ED)[1]. Our analysis is based on the complete registry of attendances at Gaslini ED in 2015, comprising 37,767 accesses (43 % of regional pediatric attendances). The registry contained information on the demographic characteristics of patients (month and year of birth, sex, and nationality) and details of each attendance (time of arrival, time of the first physician assessment, time of discharge, triage code, and outcome). However, 977 records were removed from the analysis because they were incomplete. An outlier analysis of waiting time distribution resulted in the exclusion of a further 30 cases.[2] Therefore, the total number of cases included in this study was 36,760.

This study was conducted as part of routine monitoring in the ED of the hospital; therefore, ethical approval was not required. Hospital management, the prerogative of whom it is to oversee the ethical aspects of all hospital activities, approved the study protocol, as required for all studies conducted in the hospital environment.

On arrival, all patients signed an informed consent form pertaining to treatment provided in the hospital. This research was conducted in accordance with the Italian law on privacy.[3] Patients were assigned a "patient ID" in order to guarantee their anonymity and privacy.

The information contained in the dataset allowed us to compute several additional variables that were useful for assessing the robustness of the assigned triage code. The main variable of interest was the waiting time between triage and time of physician initial assessment and treatment. We aimed to identify the determinants of ED waiting time to detect the relative impact of a set of regressors on the time to the first physicians' assessment and treatment for urgent and non-urgent triaged patients. Therefore, this variable represents the dependent variable in our model. Regressors included variables derived from two different domains: patient characteristics (age and nationality) and variables related to congestion and other contingent features of the ED at the specific moment of use. The latter set of regressors is intended to provide a proxy for identifying overcrowding. As it was not feasible to compute a multivariate measure of overcrowding [34], such as the National Emergency Department Overcrowding Scale (NEDOCS) or the Emergency Department Work Index (EDWIN), due to a lack of necessary information in our dataset, we used proxy measures for identifying the patient flow (i.e., the number of urgent and non-urgent patients waiting in the ED per 2-h slots[4]) and "supply side" variables, particularly the periods of possible staff shortage (i.e., dummy for night shifts; dummy for non-working days).[5] A further variable was included to control for the means of transport to the ED: the dummy variable was equal to 1 if the patient arrived on his/her own, while it was assigned a value of 0 if the patient arrived by ambulance/helicopter.

In order to analyze the determinants of waiting times for urgent and non-urgent patients we implemented several models in the survival analysis framework, assuming as "endpoint" the end of the waiting time for each patient. For a better understanding of these patterns, we studied waiting times as a function of the regressors in Table 1. As the Cox's proportional hazards regression assumptions were tested and violated, we estimated the model using a Parametric Survival Model using the *survreg* function of the survival package in R environment. For both types of patients (urgent and non-urgent), we estimated models using the following distributions for the response variable: "Gaussian," "exponential," "weibull," "loglogistic," "lognormal," and "logistic." Using the Akaike Information Criterion (AIC, see Table 2) to select the best model, we chose the "loglogistic" family to model Urgent patients' "survival" times and the "weibull" family for non-urgent patients (corresponding AIC values are bolded in Table 2).

[1] Data refer to accesses, not to the number of patients. In other words, patients who accessed ED many times per year were counted multiple times.

[2] We dropped 25 non-urgent patients waiting for over 500 min and five urgent patients waiting for over 300 min due to an administrative failure of the medical staff to close the cases on the patient-tracking system.

[3] Decreto Legislativo 30 giugno 2003, n. 196.

[4] Day and night shifts were split into 2-h slots and the number of urgent and non-urgent patients attending the ED during the 2-h time slots was used to assess ED flow.

[5] Gaslini Children's Hospital Emergency Department is both a medical and a surgical pediatric emergency department. It includes the Short Term Intensive Observation (eight beds) and the Emergency Medicine Ward (12 beds). There is one single medical team working in all sections of the Department, while there are two different nursing teams and two head nurses, one for the ER and one for the Emergency Medicine Ward.

The medical staff of the Emergency Department is supplemented by additional surgical staff belonging to the Pediatric Surgery Unit of the Hospital.

Day shift (12 h; 365 days): n. 2 pediatricians and n. 1 pediatric surgeon.

Night shift (12 h; 365 days): n. 1 pediatrician and n. 1 pediatric surgeon.

Furthermore, n. 1 radiologist and n. 1 technician in medical radiology are always available 24 h a day in the Emergency Department.

Regarding ER nursing staff (excluding the Emergency Medicine Ward, which has a dedicated nursing team), there are six shifts of n. 4 nurses each, n. 4 day shift nurses and n. 1 head nurse. The ER medical and nursing staff is supplemented by n. 1 healthcare assistant.

Table 1 Variables used in the model

Variable	Description
Waiting time	Waiting time before undergoing the first physicians' assessment and treatment (in minutes)
Age	Age (in months)
Foreign	Dummy variable = 1 if the patient is of foreign nationality
Direct access	Dummy variable = 1 if the patient arrives on his/her own.
Night shift	Dummy variable = 1 admission during night shifts (8.00 pm–8.00 am)
Public holiday	Dummy variable = 1 admission during non-working days
Urgent patients in the slot	Number of urgent patients (yellow and red triage code) accessing the ED in the selected 2-h slots
Non-urgent patients in the slot	Number of non-urgent patients (white and green triage code) accessing the emergency department in the selected 2-h slots

Table 2 Akaike Information Criterion (AIC) for "Gaussian," "exponential," "weibull," "loglogistic," "lognormal," and "logistic" models

Model distribution	Urgent	Non-urgent
Loglogistic	**33,662.69**	315,445.03
Weibull	34,086.91	**313,243.06**
Exponential	34,562.86	313,277.22
Lognormal	36,230.08	316,455.60
Logistic	36,254.74	339,503.02
Gaussian	38,187.10	343,348.19

Bold values identify the models selected for the analysis

3 Results

During 2015, the average number of patients per day attending the Gaslini ED was 101. More patients attended during the day shift than during the night shift (mean: 71 vs. 30). The maximum number of daily attendances was 145. The majority of these attendances (88 %) were non-urgent, while yellow and red triaged patients represented approximately 12 % of overall attendances.

Table 3[6] indicates that the modal classes of attendances during day and night shifts were 60–69 patients (100 days per year) and 30–39 patients (153 days per year), respectively. Columns 3 and 4 in Table 3 report the details of the average number of attendances per night/day shift depending on triage code assignment level (urgent or non-urgent) and per patient flow classes. The average number of patients for each class was computed on the days of the year in which the number of patients fell within the class interval.

In addition, during the days with the highest number of patients, the average number of urgent code patients remained close to its annual value. The number of urgent patients is slightly overrepresented during days and nights with particularly high number of patients: for example, during the days recording the highest patient census (100+ patients), on average, there were 12 urgent-coded patients compared to a yearly average of eight. Examining the results for non-urgent accesses, it emerged that the number of non-urgent patients (white, green codes), during days and nights with high number of patients, substantially exceeded the annual average. It is important to understand if this phenomenon has consequences on the waiting time of urgent patients who have to be treated as soon as they reach ED. Consequently, the first step of the statistical analysis focused on the distribution of patient waiting times. On average, patient waiting time to the first doctor's assessment and treatment was 45 min. Non-urgent patients waited 49 min on average before the first physicians' assessment and treatment, with a median waiting time of 30 min. Urgent patients waited 16 min on average, while 50 % of these patients waited less than 12 min. Overall, 64 % of urgent patients waited less than 15 min, representing the upper limit of compliance with urgent patients' safety standards ("Progetto Mattoni" of the Italian Ministry of Health, [35]). Non-urgent patients were mostly attended in a short time but the right tail of the distribution was, as expected, higher than that of urgent patients; 67 % of non-urgent patients waited over 15 min. The last two columns on the right side of Table 3 provide the average waiting times for urgent and non-urgent patients during night/day shifts and in relation to the number of patients accessed during the day (by patient class). The waiting time of non-

[6] All of the analyses discussed below are based on the records of the 36,760 admissions at the Gaslini ED. This large number of observations determines that all the statistical tools herein applied may detect statistically significant effects with a sensibility that is far higher than that generally used by policy makers. For instance, due to the large sample size, even small differences in mean among groups may be statistically significant albeit such a difference may not be relevant to the policy maker. Therefore, here we discuss the results of the analyses, focusing on what the statistical models outline as statistically significant, but we also take into account the absolute values of what is detected to be significant.

Table 3 Average number of attendances per night/day shift and per patient flow class

	Number of patients (classes)	Class frequency	Average number of attendances		Average waiting time (min)	
			Urgent	Non-urgent	Urgent	Non-urgent
Day shift	30–39	4	3.11	35.23	19.42	21.63
	40–49	15	4.64	42.15	11.33	26.83
	50–59	50	5.91	50.07	13.56	35.22
	60–69	100	7.69	56.91	16.27	40.63
	70–79	95	8.68	65.42	16.75	49.43
	80–89	71	9.80	74.45	18.59	54.19
	90–99	24	10.85	82.60	18.60	60.69
	100+	6	12.45	91.21	17.18	60.38
	Total	365	8.48	64.71	16.79	47.25
Night shift	10–19	31	2.37	15.21	12.15	36.06
	20–29	150	3.51	21.86	15.08	45.22
	30–39	153	5.19	28.73	15.98	57.40
	40–49	30	6.31	36.02	14.81	60.44
	50–59	1	9.00	41.00	24.11	74.24
	Total	365	4.49	25.97	15.42	52.43

urgent patients was affected by the number of patients in the slot. The average waiting time increased with the number of patients accessing during the day. Furthermore, longer waiting times were recorded during night shifts. Conversely, the waiting time of urgent patients both during night and day shifts was not influenced by patient flow. Examining Fig. 1, the kernel distributions of the two waiting times follow the usual and expected positively skewed pattern for this type of data. This pattern is confirmed by the box-plots on the right part of Fig. 1.

As stated above, the challenge of the triage coding system is to guarantee a reasonable waiting time for urgent patients, which includes periods of high patient flow and staff shortage. The next step of our analysis examined the determinants of waiting time to the first physicians' assessment and treatment according to the urgency of interventions needed by patients, controlling for determinants of delays in treatment.

In Fig. 2 we set out the Kaplan-Meier survival curves for both urgent and non-urgent patients and it is immediately obvious how the waiting time of the urgent patients drops much more rapidly than that of non-urgent patients.

Table 4 shows the results of the modeling of waiting times for non-urgent and urgent patients. Waiting time for non-urgent patients is significantly affected by most of the regressors. Specifically, among demographic characteristics, waiting time is negatively affected by age, and positively affected by foreign nationality. Non-urgent patients tended to wait longer if they attended on their own or if they attended during night shifts. Waiting time for non-urgent patients was also positively influenced by the number of urgent and non-urgent patients attending during the 2-h slot. Among urgent patients, only three regressors significantly and positively affected urgent waiting times: age, direct access, and the number of urgent patients accessing the slots.

4 Discussion

This analysis is significant as it allows the investigation of a largely unexplored category of patients (i.e., children) in urgent need of care. Despite extensive research involving adults [25], the literature on the effectiveness of the triage system in a pediatric context is limited. However, it is clearly important that future studies focus specifically on triage in the context of pediatric EDs.

The results reported in Table 4 allow us to identify the most important determinants of waiting time for urgent and non-urgent patients. Our analysis evaluated the effectiveness of the triage coding system in a pediatric context. Therefore, we were mainly interested in interpreting the coefficients relative to the variables "Number of urgent patients in slot" and "Number of non-urgent patients in slot." The results of the analysis show that the waiting time for urgent patients is not affected by the number of non-urgent patients present in the slot. This represents an important result, corroborating the effectiveness of the triage system in a pediatric context in prioritizing urgent patients. Our findings are consistent with previous studies

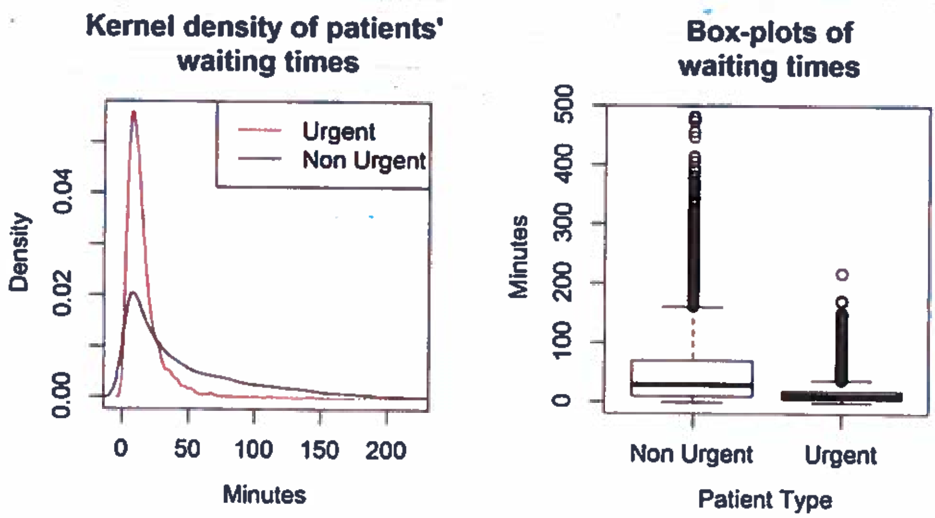

Fig. 1 Kernel density estimation of patient waiting time and box plots of waiting times for urgent and non-urgent patients

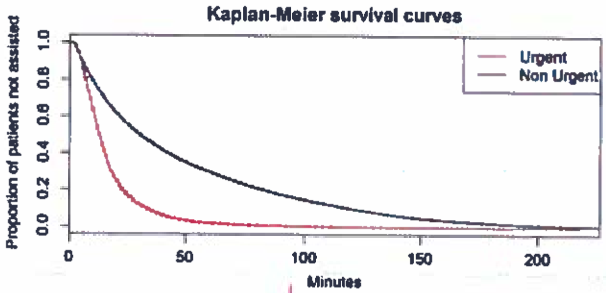

Fig. 2 Kaplan-Meier survival curves

involving adult populations. Schull et al. [26] showed that the number of low complexity patients attending the EDs had only a negligible effect on waiting times of other ED patients. Similar results have been reported by McCarthy et al. [36], concluding that the highest severity level patients represented the only category of patients not affected by ED overcrowding.

Concerning the effect of demographic factors, age affects urgent and non-urgent waiting times differently. Specifically, age negatively affects the waiting time for non-urgent patients, with longer waiting times recorded for infants and newborn children. This result may be due to the well-recognized issue of parent inexperience and excessive anxiety [32, 33]. The difficulties encountered by parents in interpreting the health status of pre-verbal children are responsible for the high prevalence of inappropriate use of emergency services during the first months of life and, therefore, for the longer waiting times; communication

Table 4 Results of the survival analysis involving non-urgent and urgent patients

	Non-urgent patients model			Urgent patients model		
	Value	SE	Significance	Value	SE	Significance
(Intercept)	3.2946	0.0261	***	2.1491	0.0434	***
Age	−0.0005	0.0001	***	0.0004	0.0001	***
Direct access	0.1304	0.0180	***	0.1744	0.0248	***
Foreign	0.2107	0.0205	***	0.0151	0.0411	
Night shift	0.2228	0.0142	***	0.0148	0.0267	
Public Holiday	0.0238	0.0147		0.0452	0.0299	
Number of urgent patients in slot	0.0996	0.0047	***	0.0478	0.0092	***
Number of non-urgent patients in slot	0.0258	0.0016	***	0.0060	0.0030	
Log(scale)	0.0258	0.0043	***	−0.7871	0.0124	***
	Scale = 1.03			Scale = 0.455		
	Weibull distribution			Log logistic distribution		
	Loglik (model) = −156612.5 Loglik (intercept only) = −157215.7			Loglik (model) = −16822.3 Loglik (intercept only) = −16871.7		
	Chi-square = 1206.43*** (7 degrees of freedom)			Chi-square = 98.64*** (7 degrees of freedom)		

Significance codes: *** 0.001; ** 0.01; * 0.05

problems are indeed a major issue in pain assessment for those patients who can only express themselves by crying. In these circumstances, it can be difficult for physicians to understand whether the crying is due to pain [37, 38]. The reverse situation occurs with urgent patients: age impacts positively on waiting time, as infants accessing the ED for urgent problems require specific attention as they represent a particularly vulnerable category of patients, comparable to the elderly in the adult ED. It is also clear from Table 4 that non-urgent foreign patients tend to wait longer than Italian patients. This rather surprising result can be explained by the presence of linguistic and cultural barriers, the requirement for an interpreter, and the lack of patient knowledge of ED functioning. All these factors may be responsible for delays in treatment compared to native patients.

The considerations above raise important issues related to equal access to services. EDs should guarantee equitable waiting times and clinical need should be the main determinant of differences in waiting times, while differences attributable to socio-demographic characteristics (for example, foreign nationality) should be limited. However, previous studies [39] identified an association between significantly higher waiting times and foreign nationality of patients.

With regard to the means of arrival to the ED, our model shows that for both urgent and non-urgent patients, waiting times were higher for patients arriving at the ED on their own, compared to those arriving by ambulance/helicopter who are likely to follow a prioritized ED admission pathway. Similar results have been previously reported by Mohsin et al. [39].

Previous studies (e.g., Goodacre and Webster [40]) show that time of presentation to the ED represents a relevant determinant of waiting times. In the setting examined here, the likely staff shortage during night shifts significantly affects only non-urgent patient waiting time, while during non-working days no critical issues have been identified for either urgent or non-urgent patients. We found that the time of presentation to the ED was only relevant for non-urgent patients, suggesting that the Gaslini ED can cope well with urgent patients even in the presence of staff shortages.

Similar to the elderly population, children are at particular risk of using ED facilities inappropriately; non-urgent pediatric attendances represent a significant proportion of overall attendances [41, 42], although this should be discouraged through strategies such as network of pediatricians [43]. Consequently, there is the risk that policies addressing the reduction of overall waiting times could favor non-urgent patients, at the expense of urgent ones. This means that if policy makers invest resources to expand ED capacity and decrease (overall) waiting times, this may encourage inappropriate patients to receive care at EDs instead of the other (more appropriate) services provided by the regional/national health system.

5 Limitations

It is important to consider that this study is a retrospective analysis, based on administrative data that were not collected primarily for research purposes. Therefore, the selection of some of the variables, particularly sociodemographic characteristics of patients, was constrained by data availability. Furthermore, as set out in the Data section, the multivariate nature of overcrowding makes it necessary to further specify that this study is based on proxy measures of ED flow and staff shortage due to the impossibility of collecting additional data from the ED as no information is available on the number of physicians and nurses on duty.

The current study is based on the assumption that patients were correctly classified according to triage codes. This may be a limitation to this study, as previous literature on the effectiveness of the triage system in the pediatric context highlights the difficulties of nurses to correctly classify pediatric patients [30]. However, Piccotti et al. [44] showed that, even if improvement of the guidelines may improve triage compliance, the overall performance of the Gaslini ED patient classification can be considered satisfactory.

6 Conclusion

Our results suggest that the triage system can be considered robust in the presence of a high number of patients and in periods of staff shortage. While the waiting time for non-urgent patients is affected by a number of demographic and contextual variables, the waiting time for acute patients tends to be affected by the presence of other urgent patients in the ED, and, secondarily, by age and means of arrival. These results are important for a number of reasons. First, the fact that the safety of urgent patients is guaranteed, regardless of the presence of staff shortage or excessive ED flow, suggests that the current organization of the ED is adequate to fulfill its primary goal of providing healthcare for urgent patients. Therefore, if we consider waiting times for urgent patients as the key indicator to assess the overall performance of the triage system, the performance of the analyzed pediatric ED can be considered satisfactory. Second, it has been reported that non-clinical factors, namely age and nationality, affect waiting times, particularly for non-urgent patients. These results may contribute to the development of standardized triage guidelines to reduce the impact of these factors on waiting times. These initiatives may be helpful in the reduction of cultural and linguistic barriers responsible for longer waiting times for foreign individuals and in improving pain assessment for pre-verbal children who can only express their pain by crying.

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Authors' contributions Although all authors contributed to the conception of the study, the design of the study, and writing of the manuscript, MM and PP can be identified as the guarantors for the overall content and interpretation of the results. EdB and LL are responsible for the data analysis. PP is the provider of the data used for the analysis.

Compliance with ethical standards

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Conflict of interest The authors (Marcello Montefiori, Enrico di Bella, Lucia Leporatti, and Paolo Petralia) have no conflicts of interest to declare.

Ethical statement The study was carried out as part of routine checks conducted in the ED of the hospital and so ethical approval was not required. As is the case with all studies conducted in the hospital environment, the management of the hospital approved the study protocol. The management is responsible for ensuring the ethical aspects of all hospital activities.

Informed consent On entering the hospital, all patients sign an informed consent form regarding treatment in the hospital.

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