Effects of Emergency Department Crowding on the Delivery of Timely Care in an Inner-City Hospital in the Netherlands

Running head: Delivery of timely care during ED crowding

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Abstract:

BACKGROUND: The impact of delays in emergency department (ED) care has not been described in European countries where ED crowding is not universally recognized. The aim of this study is to determine the relationship of ED crowding to delays in triage, treatment, and 24-hour mortality in patients admitted from the ED. METHODS: Five years of data for adults admitted to the hospital were analysed retrospectively from an inner-city ED in the Netherlands. Variables included: crowded versus non-crowded time, time to triage, triage category, time to treatment, age, 24-hour mortality, and 10-day mortality. RESULTS: 39,110 patients met inclusion criteria. ED crowding occurred 30.8% of the time. There were no differences in mortality between patients arriving during crowding versus non-crowding. Delays in triage during ED crowding occurred 29.7% of the time versus 14.6% during non-crowding. Delays in treatment occurred 11.7% versus 7.3%, respectively. CONCLUSION: In this hospital, ED crowding results in increased time to triage and treatment, not in 24-hour or 10-day mortality.

Keywords Emergency Service, Hospital; Emergency Department crowding; Overcrowding; Patient Outcome Assessment; Mortality;

Introduction One of the most critical issues affecting emergency department (ED) delivery of care worldwide is crowding. ED crowding has been defined as a state in which the demand for emergency care outweighs the accessible resources [1-3]. Crowding is associated with a number of impaired care processes and negative patient outcomes [4-6] such as delays in treatment [7] and increased risk of adverse outcomes [2, 8, 9]. ED crowding often results from insufficient inpatient hospital capacity and the boarding of patients in the ED for extended periods of time [3, 10]. Thus, ED length of stay (LOS) indirectly reflects hospital crowding.

Mean ED LOS for admitted patients in the Netherlands (146, SD ±49 minutes) [11] is short compared to other countries [12, 13]. This is probably one of the main reasons that Dutch policy makers do not perceive ED crowding to be a major problem. Many ED managers in the Netherlands however report having problems with ED crowding a few times per week [11].

During ED crowding the demand for emergency services exceeds the ability to provide quality care within appropriate time frames.

<u>What are appropriate time frames?</u>

Within emergency care, ‘quality of care’ and ‘timely care’ are closely related. Long waiting times are associated with delays in time-sensitive treatments [14, 15]. Delays in the initiation of appropriate treatments lead to an increased risk of adverse outcomes [16]. Target times to triage and treatment are based on the Dutch guideline of triage [17]: patients should be triaged within 5 minutes, and assigned with a triage decision within 10 minutes after arrival. No formal guidelines exist regarding total ED LOS.

The objectives of this study were to investigate crowding measures (ED occupancy, ED LOS, elapsed target time to triage and elapsed target time to treatment, patients staying more than 4 hours in the ED) to describe how the ED copes with current demands. Furthermore, we assessed the effect of the ED occupancy rate on mortality within 24 hours and 10-days of admission. Our hypothesis was that high ED occupancy would be associated with an increase in 24-hour and 10-day mortality.

Methods

Design and Setting

We performed a retrospective cohort study of adult admissions through the ED of Medical Centre Haaglanden (MCH) Westeinde between January 1, 2009 and December 31, 2013. The MCH Westeinde is a mixed adult and paediatric inner-city hospital in the Netherlands, with 50,000 ED visits annually. The 20-bed ED serves as a regional trauma centre and is available for 24-hour acute neurological interventions. All patients are registered into the hospital database before they go to triage. During peak hours there is a shortage of treatment rooms.

Data Collection and Processing

The ED occupancy rate [18] (total number of patients in the ED divided by the total number of ED beds) was used as main indicator of ED crowding and was assessed from hospital records. The numerator included all patients (including children and patients who were not admitted) who were under treatment in the ED at any point, regardless of ED location. The denominator included the total number of ED beds. For each included patient, the ED occupancy rate at the time of arrival was calculated. The higher the occupancy rate, the more crowded the ED. An ED is crowded when the occupancy rate is >1.0 [19].

Other crowding measures used in this study were ED LOS, percentage of patients with elapsed target times to triage, percentage of patients with elapsed target times to treatment, and the percentage of patients staying more than 4 hours in the ED, based on the crowding measures as suggested by

Beniuk et al. [20]. The effect of ED occupancy on 24-hour and 10-day mortality was assessed by comparing patients arriving during hours with ED crowding to patients arriving during hours without ED crowding.

Included were adult patients who were admitted to the hospital. Excluded were patients younger than 18 years, because ED crowding may have different effects in paediatric compared to adult populations [21]. Also excluded were adult patients who arrived in the ED dead on arrival (DOA) or with cardiopulmonary resuscitation (CPR) in progress, patients who were transferred from other hospitals and patients who were transferred to other hospitals or nursing homes.

Patient and visit characteristics were extracted from the hospitals' database. Referral status and EMS transport were not routinely collected in 2009 and 2010, so these data were obtained only for 2011, 2012 and 2013.

The Medical Ethics Committee exemption was granted.

Analyses

Data were analysed using predictive analytics software (SPSS, version 20; SPSS Inc., Chicago, Illinois, USA). For continuous data the median and interquartile range (IQR) are presented. Differences in patient and visit characteristics, patient transit times, 24-hour mortality and 10-day mortality, between crowding and non-crowding were tested using χ^2 tests and Mann-Whitney U-tests. We used multiple imputation methods to impute values for missing data; all variables were complete, except for age and triage level, which were missing up to 1 %, and self-referred and EMS transport, which had 37 % missing values. We assumed these values to be missing at random, conditional on the year.

Multiple imputation is a statistical technique that uses observed data to obtain plausible values for the missing items. As opposed to complete case analysis or dropping the variables with missing values from the analysis, multiple imputation has shown to generate reliable results, even with proportions of missing data much higher than 37% [22].

The literature suggests that the proportion of missing covariate data not necessarily determines whether multiple imputation can be used, but rather the number of observations that is left [22]. We generated 5 imputed datasets using SPSS.

The independent impact of patient and visit characteristics on the presence of 24-hour and 10-day mortality were analysed using logistic regression, adjusting for the other variables. The estimates from the logistic regression models from the imputed datasets were combined using Rubin's methods [23, 24], and expressed as adjusted odds ratios (OR) with 95% confidence intervals (CI). The calibration and overall discriminative capacity of the combined model was assessed with the Hosmer-Lemeshow test and the area under the receiver operating curve (AUC ROC).

Results

Throughout the study period, 251,913 patient visits were registered at the ED. 41,439 visits (16.4%) were made by patients younger than 18 years of age. Of the adult patient visits, 168,770 visits (67.0%) ended in discharge from the ED without hospital admission. Excluded from analysis were 1,242 visits of patients who arrived in the ED with CPR in progress, 424 visits of patients who were transferred from other hospitals and 928 visits of patients who were transferred to other hospitals or nursing homes. Thus, 39,110 visits (15.5% of total ED visits) met inclusion criteria (Figure 1).

The median number of patients occupying the ED per hour was 16 (IQR 12), ranging from 1 patient to 57 patients. The median ED occupancy rate was 0.8, ranging from 0.05 to 2.85. Of the patients, 30.8% (n=12,448) arrived during crowding (ED occupancy rate >1) and 68.2% of the patients (n=26,662) arrived during non-crowding (ED occupancy rate $\leq$1). Baseline data and differences in patient and visit characteristics between crowding and non-crowding are presented in Table 1.

Patients who arrived during crowding more often had delayed target times to triage: 29.7% of the patients during crowding versus 14.6% during non-crowding (p<0.001). Delayed target times to treatment were experienced by 11.7% of the patients during crowding versus 7.3% during non-crowding (p<0.001).
There was a significant difference in ED LOS between patients who arrived during crowding (median LOS 220 (IQR 132) minutes) and patients who arrived during non-crowding (median LOS 200 (IQR 126) minutes, p<0.001). During crowding significantly more patients stayed more than 4 hours in the ED compared to during non-crowding (42.5% vs. 34.0%, p<0.001).

Of the total number of patients enrolled in this study, 392 patients (1%) died within 24 hours after ED arrival; 1.0% (124 patients) had arrived during crowding, and 1.0% (268 patients) had arrived during non-crowding (p=0.933).
There were 1,382 patients who died within 10 days of admission; 447 patients (3.6% of total patients) had arrived during crowding, and 935 patients (3.5% of total patients) during non-crowding (p=0.675) (Table 2). Table 3 shows the adjusted OR and 95%CI of each patient and visit characteristics associated with mortality. Arriving during crowding was not associated with overall mortality. The odds of 24-hour mortality increased significantly when the patient was older, and when the patient was allocated an immediate or high-urgent triage level. Analyses of the 10-day mortality showed that associated factors were roughly the same as for 24-hour mortality (Table 3). The Hosmer-Lemeshow tests were not significant, indicating a good fit of the combined models.

Accuracy of the combined models as obtained by the AUC ROC was 0.85 (95%CI 0.84-0.87) and 0.81 (95%CI 0.80-0.82), respectively.

Limitations

The results of this study must be interpreted in the context of the following limitations. First, our study was a retrospective study. We had no information regarding comorbidity and severity of illness other than triage level, limiting the possibilities to correct for these potential confounders. Second, we used a crude measure of crowding: ED occupancy ≥100%. More sophisticated crowding measures such as the International Crowding Measure in Emergency Departments [25] and the National Emergency Department Overcrowding Score [26] are not available in our setting.

To account for the variation in crowding during the day, we calculated the occupancy rate using the total number of patients present at the arrival time of each admitted patient, leading to an individual occupancy score per patient. We acknowledge that this method does not account for differences in triage levels of the other ED patients, differences in boarding times and differences in number and experience of ED staff. Moreover, during the course of a patient's stay at the ED, crowding levels may fluctuate [18]. However, changes in occupancy rates were significantly associated with other crowding measures (elapsed target time to triage, elapsed target time to treatment and total ED LOS), enhancing trust in this feasible measure of crowding.

Third, we cannot rule out admission bias: ED patients may be more likely to be admitted when the ED is crowded. The ED staff's ability to safely discharge patients may be compromised during crowding [19]. Therefore, patients admitted during ED crowding may be less ill than patients who are admitted during non-crowding. This phenomenon could explain why 24-hour mortality did not increase during crowding. Fourth, some patients discharged from the ED may have died without being transferred back to the study setting. Finally, generalizability of this study may be limited to

EDs in similar settings. Nevertheless, since we used objective measures of ED crowding, we expect that our results are useful for many other EDs: crowding occurs even in EDs with relatively short LOS.

Discussion

To our knowledge, this is the first study to quantify ED crowding and its effect on both 24-hour and 10-day mortality in a country where ED crowding is not fully recognized. Patients who arrived during crowding more often had elapsed target times to triage and treatment, compared to patients who arrived during non-crowding. Patients arriving during crowding also significantly more often had a LOS of 4 hours and longer. Their median ED LOS was 20 minutes longer than for patients who arrived during non-crowding. Presentation to the ED during crowding was not associated with increased mortality in patients who were admitted to the hospital.

There is no universal definition for ED crowding in the Netherlands. In this study, we used the ED occupancy rate [18] as main crowding measure. Since its introduction, researchers have demonstrated that high ED occupancy rates are associated with poor treatment quality and clinician's opinion of crowding [13, 27-29]. Other measures used in our study are based on the crowding measures as defined by Beniuk et al. [20] and present a comprehensive view on how crowding affects ED operations. Elapsed target times to triage and to treatment occurred during crowding as well as during non-crowding, which may indicate that crowding occurs even below an occupancy rate of 1.

In several international studies an association between ED crowding and patient mortality was sought [8, 9, 13, 16, 30-32]. Cha et al. (2011) reported that 30-day mortality was significantly greater among paediatric patients exposed to ED crowding, versus those not exposed to crowding [30]. Guttman et al. (2011) found that the risk for 7-day death among patients discharged from the

ED was greater among those who visited the ED during shifts with mean LOS>6 hours than those who presented to the ED during shifts with mean LOS<1 hour [16]. In the study of Jo et al. (2014), crowding as measured using the ED occupancy ratio was associated with 1 to 3-day mortality, but not with 4 to 7-day mortality [13]. Plunkett et al. showed that both door-to-team as team-to-ward times were independent predictors of death within 30 days [31], and Richardson (2006) reported that the risk of 10-day inpatient mortality for patients admitted to the hospital during ED crowding was 34% higher compared to those admitted during non-crowding [8]. Sprivulis et al. (2006) found that hospital and ED crowding was associated with increased mortality [9], and Sun et al. showed that patients who were admitted on days with high ED crowding experienced 5% greater odds of inpatient death [32]. Another study found no effect of ED crowding on mortality [12]. In our study, we investigated 24-hour mortality and 10-day mortality, but neither increased during crowding. It is possible ED personnel adapts to crowded conditions to prevent adverse events.

Although it is reassuring that mortality did not increase during crowding, other important processes of care may be impeded during crowding. We did not measure the effect of ED crowding on patient satisfaction, admission LOS, delays in getting antibiotics and analgesia, and many other patient outcomes.

The findings that the number of patients with elapsed target times to triage and to treatment increased during crowding is certainly not reassuring, since both jeopardize the quality of care. Finding solutions to ED crowding is an important challenge for hospital administrators and ED staff. A future prospective study should include the follow-up of patients who were discharged from the ED, to assess mortality 10 days after discharge. Furthermore, it might be interesting to study the impact of crowding on mortality at a more aggregate level. While this study did not show an association between crowding and mortality at the individual level, such an association might exist at the aggregate level, for example explaining mortality differences between EDs.

Conclusions

Periods of ED crowding impair the delivery of timely care, even in an ED with relatively short LOS. Although ED crowding does not seem to influence overall inpatient mortality in this hospital, elapsed target times to triage and elapsed target times to treatment are major patient safety concerns.

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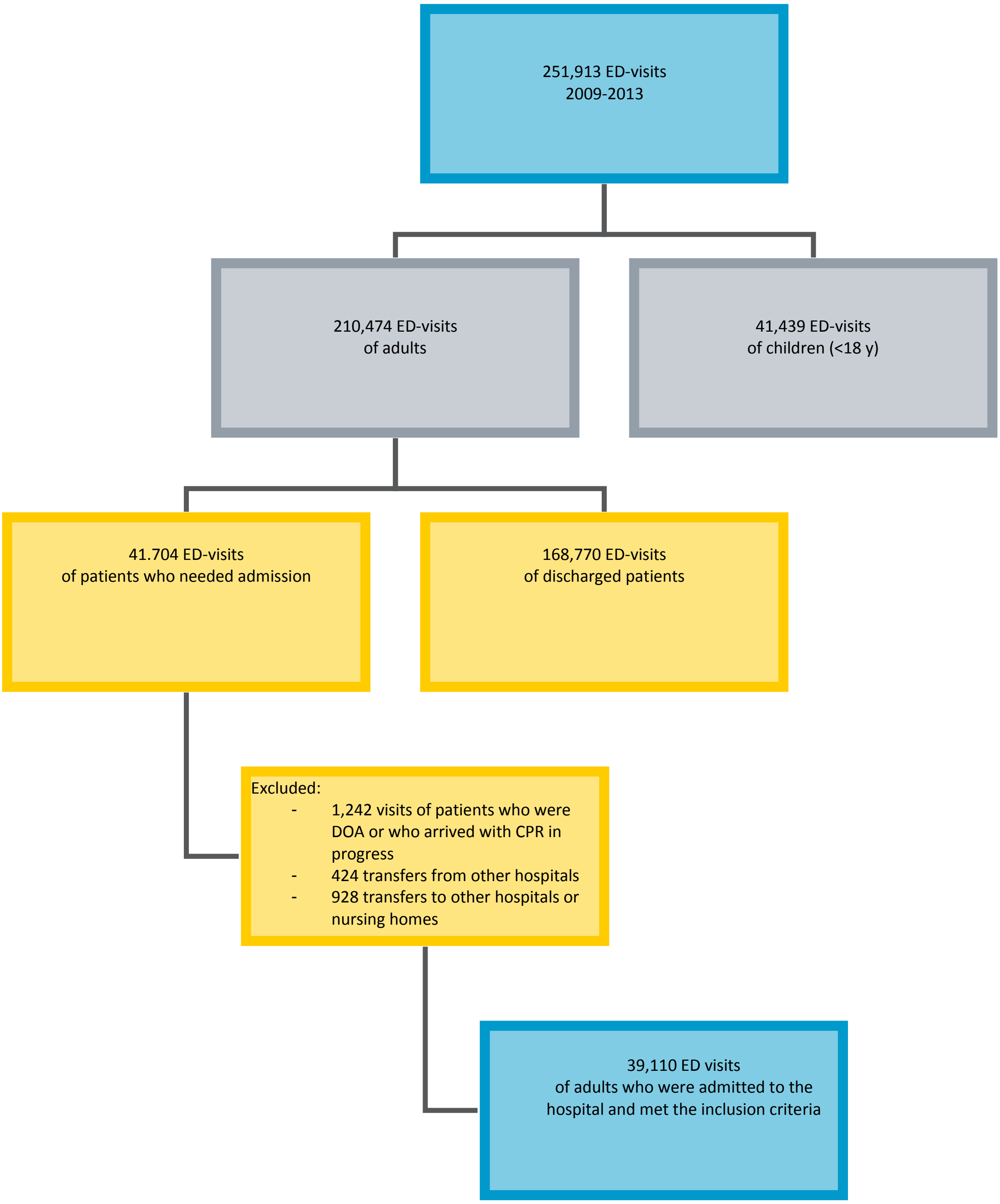
Legends for illustrations

Figure 1. Study flow chart



DOA, dead on arrival; CPR, cardiopulmonary resuscitation;

Table 1. Baseline patient and visit characteristics (N=39,110)

Variables	ED Crowding (n=12,448)	No ED crowding (n=26,662)	*p*-value[a]
Age in years, median (IQR)	61 (29)	60 (29)	<0.001
18-34, % (n)	12.7 (1,584)	14.6 (3,883)	<0.001
35-54, % (n)	24.9 (3,096)	25.9 (6,918)	0.023
>55, % (n)	62.4 (7,768)	59.5 (15,860)	<0.001
Sex, male, % (n)	49.8 (6,195)	52.4 (13,974)	**<0.001**
Registration day, weekend, % (n)	17.6 (2,188)	29.5 (7,866)	**<0.001**
Time of arrival, % (n)			
Day shift (8.00 am–2.59 pm)	33.9 (4,222)	45.2 (12,053)	**<0.001**
Evening shift (3 pm–10.59 pm)	64.7 (8,050)	29.8 (7,947)	**<0.001**
Night shift (11 pm-7.59 am)	1.4 (176)	25.0 (6,662)	**<0.001**
Self-referred, % (n)	20.9 (2,604)	23.5 (6,268)	**<0.001**
EMS[d] transport, % (n)[b]	32.0 (3,983)	37.3 (9,934)	**<0.001**
Triage level, % (n)			
Immediate and high urgent	44.5 (5,540)	47.3 (12,619)	**<0.001**
Urgent	45.3 (5,639)	42.3 (11,288)	**<0.001**
Standard and non-urgent	10.2 (1,269)	10.3 (2,755)	0.701
Medical specialty, % (n)			
Internal medicine	27.4 (3,409)	24.9 (6,652)	**<0.001**
Cardiology	20.5 (2,554)	21.7 (5,783)	**0.008**
Neurology and neurosurgery	21.1 (2,624)	20.7 (5,530)	0.443

Surgery	15.4 (1,914)	17.1 (4,551)	**<0.001**
Respiratory	8.5 (1,054)	8.5 (2,268)	0.897
Gynaecology	2.7 (341)	2.8 (743)	0.790
Orthopaedics	2.1 (265)	2.1 (548)	0.635
Urology	1.3 (160)	1.3 (336)	0.836
Other[c]	1.0 (127)	0.9 (251)	0.458
Admission ward, % (n)			
Intensive care unit	4.6 (576)	5.4 (1,452)	**0.001**
Coronary care unit	18.9 (2,349)	19.8 (5,288)	**0.025**
General ward	76.5 (9,523)	74.7 (19,922)	**<0.001**

[a] The χ^2 test was used for all variables, except for age, which was analysed with the Mann-Whitney U-test; [b] EMS, emergency medical service; [c] Specialism occurring less than 400 times per year (including dental, oral and maxillofacial surgery, dermatology, ophthalmology, otorhinolaryngology, plastic surgery, psychiatry, radiotherapy, radiology and rheumatology) were categorized as ‘Other’.

Table 2. Patient transit times and 24-hour mortality

	Total N=39,110	ED Crowding n=12,448	No ED crowding n=26,662	*p*-value[a]
Elapsed target time to triage, n (%)	7,506 (19.2)	3,643 (29.7)	3,863 (14.6)	<0.001
Elapsed target time to treatment, n (%)	3,359 (8.6)	1,432 (11.7)	1,927 (7.3)	<0.001
ED LOS[b], minutes, median (IQR)[c]	206 (129)	220 (132)	200 (126)	<0.001
ED LOS[b] **>4 hours,** n (%)	14,342 (36.7)	5,286 (42.2)	9,056 (34.0)	<0.001
24-hour mortality, n (%)	392 (1.0)	124 (1.0)	268 (1.0)	0.933
10-day mortality, n (%)	1,382 (3.5)	447 (3.6)	935 (3.5)	0.675

[a] The χ^2 test was used for elapsed target time to triage, elapsed target time to treatment and mortality; The Mann-Whitney U-test was used for ED LOS; [b] ED LOS, emergency department length of stay; [c] IQR, Interquartile Range.

Table 3. Multivariable analysis: adjusted odds ratios (OR) for the predictors of mortality

	Adjusted OR[a] (95%CI), p-value	
	24-h mortality[b]	**10-day mortality**[c]
ED Crowding, occupancy rate >100%	1.16 (0.91-1.47), 0.23	1.07 (0.94-1.21), 0.34
Age, years	1.04 (1.04-1.05), **<0.001**	1.05 (1.04-1.05), **<0.001**
Sex, male	1.03 (0.84-1.27), 0.76	1.07 (0.96-1.20), 0.22
Registration day, weekend	1.30 (1.05-1.63), **0.02**	1.13 (1.00-1.28), 0.06
Time of arrival		
Day shift (8 am – 3 pm)	Reference	Reference
Evening shift (3 pm – 11 pm)	0.78 (0.61-0.99), **0.04**	0.94 (0.83-1.07), 0.36
Night shift (11 pm – 8 am)	1.08 (0.81-1.45), 0.59	1.01 (0.86-1.19), 0.90
Self-referred	0.75 (0.49-1.16), 0.19	0.65 (0.51-0.82), **<0.001**
EMS transport	1.17 (0.83-1.65), 0.36	1.29 (1.11-1.49), **0.001**
Medical specialty		
Cardiology	Reference	Reference
Internal medicine	3.19 (2.18-4.66), **<0.001**	4.56 (3.72-5.59), **<0.001**
Neurology and neurosurgery	5.55 (3.89-7.92), **<0.001**	4.46 (3,63-5.48), **<0.001**
Surgery	5.82 (3.88-8.71), **<0.001**	3.40 (2.66-4.35), **<0.001**
Respiratory	3.47 (2.25-5.36), **<0.001**	5.50 (4.38-6.89), **<0.001**
Gynaecology	1.83 (0.25-13.57), 0.55	1.46 (0.46-4.66), 0.52
Orthopaedics	2.40 (0.73-7.90), 0.15	1.82 (0.99-3.34), **0.05**
Urology	0.00 (0.00-0.00), 1.00	3.91 (2.07-7.38), **<0.001**

Other	3.38 (1.03-11.10), 0.05	5.11 (2.91-8.98), **<0.001**
Triage level		
Immediate and high urgent	38.34 (9.47-155.21), **<0.001**	6.92 (4.82-9.94), **<0.001**
Urgent	3.24 (0.78-13.55), 0.11	1.68 (1.16-2.43), **0.006**
Standard and non-urgent	Reference	Reference

[a] Adjusted for other variables by logistic regression, OR >1 indicate an increased risk of 24-hour mortality; [b] Hosmer-Lemeshow not significant, AUC ROC 0.85 (95%CI 0.84-0.87); [c] Hosmer-Lemeshow not significant, AUC ROC 0.81 (95%CI 0.80-0.82).

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