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Patients in prehospital transport to the emergency department: a cohort study of risk factors for 7-day mortality

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Background **Ambulance transfer is the first contact with the healthcare system for many patients in emergency conditions. We aimed to identify prognostic risk factors accessible in the prehospital phase that indicate an increased risk of 7-day mortality.**

Patients and methods **We included patients aged 18 years or older, transferred by ambulance to the emergency department at Odense University Hospital, from 1 April 2012 to 30 September 2014. We carried out multivariate logistic regressions, adjusted for age and sex, to describe the relationship between vital sign values recorded in the prehospital setting and 7-day mortality.**

Results **A total of 32 076 ambulance transfers were recorded. Of these, 20 328 were first-time transfers, including 2692 that received assistance from a physician-staffed mobile emergency care unit (MECU). The 7-day mortality was 5.3% [95% confidence interval (CI): 5.0–5.6]. The risk of death increased with age. The odds ratios (ORs) were 2.0 (95% CI: 1.1–3.5) for ages 30–44 years and 7.3 (95% CI: 4.5–11) for ages 45–69 years compared with the 18–29-year-olds. All abnormal vital sign values were associated with increased 7-day mortality. Glasgow Coma Score of less than 14 had the strongest association (OR: 17, 95% CI: 14.7–19.7). MECU assistance showed an adjusted OR of 5.3 (95% CI: 4.6–6.1).**

Conclusion **The overall 7-day mortality was 5.3%, but differed in the two subgroups, with 15.4% in the MECU-assisted ambulance transfers and 3.8% in non-MECU-assisted transfers. Older age and Glasgow Coma Scores below 14 were the strongest of factors associated significantly with 7-day mortality.** ***European Journal of Emergency Medicine*** **00:000–000**

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Keywords: ambulance, emergency medicine, mobile emergency care unit, mortality, prehospital, risk factor

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Background

The emergency call signals that a patient is in urgent need of medical care. The survival and quality of life in patients with critical illness depends on the clinical condition, patient-related factors, organizational set-up and the time of day or week [1–10]. Over several years, medical emergency teams and track-and-trigger systems have been developed [11]. Currently, vital sign parameters comprise one of the cornerstones for assessing and performing triage of patients in emergency departments (EDs) [12,13]. Studies on early recognition of deterioration in patients in the hospital have identified potentially recognizable patterns or signs that develop in vital parameters and clinical conditions before deterioration has led to organ failure [3,14].

This study aimed to identify the prognostic factors accessible in the prehospital phase that could indicate an increased risk of 7-day mortality.

Patients and methods

Study design and setting

This observational cohort study prospectively collected data on all adult patients transferred by ambulance to the ED at Odense University Hospital (OUH) in the period from 1 April 2012 to 30 September 2014.

OUH is a university teaching hospital that serves as a primary hospital for a mixed rural–urban contingency population of 288 000. This level-one trauma centre holds 1000 beds and it manages ~75 000 contacts per year. All adult patients with emergency conditions enter the hospital through the ED, except women in childbirth, patients currently in chemotherapy or dialysis and patients with severe cardiac diseases. In Denmark, hospital care, including prehospital transport, is free of charge as part of the tax-funded healthcare system. Severe prehospital emergency situations in the Odense area are handled by specialized physician-staffed mobile emergency care units (MECUs) on a 24 h/day basis. All MECUs are staffed by specialists in anaesthesiology, and all are associated with the Department of Anaesthesiology at OUH.

In the southern region of Denmark, the basic response to a request for prehospital medical assistance is to send an ambulance staffed with two emergency medical technicians (EMTs). In the less densely populated rural parts of the catchment area, a paramedic may be dispatched with

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the ambulance to supplement treatment when deemed necessary by the dispatch centre. Prehospital emergency care may be supplemented by sending MECUs staffed with an anaesthesiologist and an EMT. The MECU is dispatched immediately from the central dispatch call centre in life-threatening conditions, accidents likely to cause life-threatening conditions, fires, chemical exposures or when immediate anaesthesiology assistance is considered necessary by EMTs [15].

Participants

This study included all patients, aged 18 years or older, who were transferred by ambulance to the ED during the study period. We included only patients alive upon arrival and with a valid Danish personal identification number (PIN) [16]. When a patient had multiple transfers over the study period, only the first transfer was included in the analysis.

Variables and outcomes

The outcome was the 7-day mortality. Each emergency contact was linked to the Danish National Patient Registry and the Danish Civil Registration System [17,18].

Data sources and measurements

Patient data, including personal identification, chronological timestamps, symptoms and vital sign values, were routinely recorded on a structured form during each ambulance transfer. Forms were prospectively collected and data were manually entered into the database. MECU data were routinely electronically sampled in a database. After each MECU dispatch, the responsible physician completed an electronic medical record of the patient characteristics, tentative patient diagnosis, clinical condition and administered treatment.

The unique Danish PIN made it possible to extract and link supplemental information from two large population-based healthcare registries, including previous discharge diagnoses, birth date and vital status [17,18]. To validate PINs, dates and timestamps, we retrieved information from the Funen Patient Administration System, the ED logistic patient administration system and electronic patient journals.

To minimize bias from repeated measurements, we included in the analyses only first-time transfers and first recorded set of vital signs. Normal vital signs were predefined as follows: systolic blood pressure of at least 120 mmHg, heart rate of up to 90 beats/min, respiratory rate of up to 20 breaths/min, peripheral oxygen saturation of at least 95% and a Glasgow Coma Score (GCS) of at least 14 on the basis of commonly used and accepted levels.

Time was dichotomized into day or night. Night was defined as before 8 a.m. and after 8 p.m. The day of the week was dichotomized into a weekday or a weekend. Weekdays were Monday through Thursday and weekends were Friday through Sunday. Age was categorized into six subgroups.

Comorbidity was assessed in a subanalysis, graded with the Charlson Comorbidity Index (0, 1, ≥ 2). Comorbidity was defined as a condition recorded in a discharge diagnosis within 10 years before the index date [19].

Analyses

Basic patient and transfer characteristics are described as the number and percentages for each variable, and data are presented in figures with 95% confidence intervals (95% CIs). The associations between exposure variables and 7-day mortality were determined with logistic regressions. Multivariate logistic regressions, adjusted for sex and age groups, were used to determine odds ratios (ORs).

Missing values were handled as independent variables throughout the analyses.

Ethical approval

In compliance with the Danish law, this study was registered with and approved by the Danish Data Protection Agency (J No. 2013-41-2036) and the access to patient records was approved by the Danish Health and Medicines Authority (J No. 3-3013-355/1). Data were anonymized before analysis.

Results

A total of 32 076 ambulance transfers to the ED were recorded during the study period, with an average of 58 transfers per day. After excluding children and ineligible contacts, the population included 51.4% men. The 45–69-year-old age group accounted for 35.7% of the population. Most transfers occurred during the day (57.8%) and the majority of patients had vital sign values within normal reference values (Table 1). The total number of first-time transfers was 20 328, including 2692 that involved MECUs (Fig. 1).

The MECU transfers included a higher percentage of men (56.5 %) compared with the non-MECU group (50.0%). The age distributions of the two groups were approximately identical. The data for the MECU group were missing a high proportion of vital sign values, ranging from 7.8% of GCSs to 36% of respiratory rates, compared with a range from 3.7 to 8.4%, respectively, for the non-MECU transfers. The distribution of patients with comorbidities in each of the Charlson Comorbidity Index categories was almost identical for both groups (Table 2).

The overall 7-day mortality was 5.3% (95% CI: 5.0–5.6), but 7-day mortality differed between groups, with 15.4% (95% CI: 14.1–16.8) in the MECU group and 3.8% (95% CI: 3.5–4.0) in the non-MECU group. MECU assistance was associated with an OR of 4.7 (95% CI: 4.1–5.3)

Table 1 Patient and transfer characteristics, total 28 432 transfers

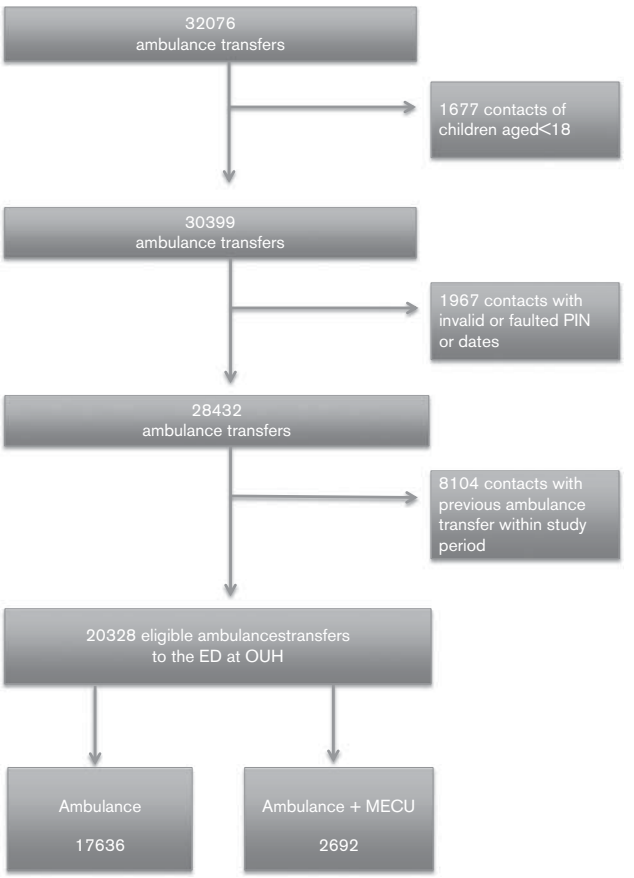
Characteristics	*n* (%)
Sex	
Female	13 829 (48.6)
Male	14 603 (51.4)
Age (years)	
18–29	3232 (11.4)
30–44	3365 (11.8)
45–69	10 143 (35.7)
70–84	7850 (27.6)
85–99	3793 (13.3)
100	49 (0.2)
Charlson Comorbidity Index	
0	12 706 (44.7)
1	5822 (20.5)
≥ 2	9904 (34.8)
Vital parameters	
$Sp0_2$ (%)	
≥ 95	20 252 (71.2)
< 95	5737 (20.2)
Missing	2443 (8.6)
RR/min	
≤ 20	19 677 (69.2)
> 20	5397 (19.0)
Missing	3358 (11.8)
SBP (mmHg)	
≥ 120	21 552 (75.8)
91–119	4199 (14.8)
≤ 90	693 (2.4)
Missing	1988 (7.0)
HR/min	
< 90	14 271 (50.2)
≥ 90	12 331 (43.4)
Missing	1830 (6.4)
GCS	
≥ 14	24 053 (84.6)
< 14	3142 (11.1)
Missing	1237 (4.4)
Time of day	
Day	16 443 (57.8)
Night	8688 (30.6)
Missing	3301 (11.6)
Weekday	
Monday–Thursday	16 164 (56.9)
Friday–Sunday	12 268 (43.1)
Ambulance	
Ordinary	24 438 (85.95)
MECU	3994 (14.05)

GCS, Glasgow Coma Score; HR, hazard ratio; MECU, mobile emergency care unit; OR, odds ratio; RR, relative risk; SBP, systolic blood pressure.

compared with ordinary ambulance transfers in crude odds and 5.3 (95% CI: 4.6–6.1) when adjusted for age and sex. Mortality increased with age in both univariate and multivariate analyses.

All abnormal vital signs were associated with 7-day mortality in both the univariate and the multivariate analysis, after adjusting for sex and age. The highest absolute mortality rates were associated with the missing vital parameter measurements in all groups. The recorded vital parameter with the strongest association to 7-day mortality was a GCS below 14, followed by systolic blood pressure of up to 90 mmHg, systolic blood pressure of 91–119 mmHg; plethysmographic oxygen saturation of less than 95%, respiratory rate of more than 20 breaths/min; and heart rate of at least 90 beats/min. The time of arrival and day of the week showed no associations with 7-day mortality (Table 3).

Fig. 1



Flowchart describing selection of the cohort. ED, emergency department; MECU, mobile emergency care unit; OUH, Odense University Hospital; PIN, personal identification number.

Overall, the ORs for abnormal vital parameters were slightly higher in the ordinary ambulance group compared with the MECU group, except for GCS below 14 (Fig. 2).

Discussion

We showed that the absolute 7-day mortality was 15.4% in MECU-assisted ambulance transfers and 3.8% in non-MECU transfers in a population of adult patients transferred by ambulance to the ED. The overall 7-day mortality was 5.3%. Older age and vital parameters beyond the normal reference ranges were associated with a higher 7-day mortality in all transfer groups. A prehospital GCS below 14 showed the strongest association.

In-hospital mortality and critical illnesses were previously shown to occur in ~5% of patients transported to the hospital [5]. Here, we differentiated between MECU and non-MECU mortality rates because of the expected differences in patient characteristics, observations and treatments. Patients considered in need of immediate MECU assistance are inherently different from patients

Table 2 Distribution of characteristics with and without mobile emergency care unit involvement

	Non-MECU [*n* (%)]	MECU [*n* (%)]	*P* value
Sex			
Female	8817 (50.0)	1172 (43.5)	
Male	8819 (50.0)	1520 (56.5)	< 0.0001
Age (years)			
18–29	2319 (13.1)	340 (12.6)	
30–44	2281 (12.9)	419 (15.6)	
45–69	6160 (34.9)	1058 (39.3)	
70–84	4631 (26.3)	623 (23.1)	
85–99	2215 (12.6)	246 (9.1)	
100	30 (0.2)	6 (0.2)	< 0.0001
Charlson Comorbidity Index			
0	9221 (52.3)	1442 (53.6)	
1	3358 (19.0)	469 (17.4)	
≥ 2	5057 (28.7)	781 (29.0)	0.130
Vital parameters			
SpO_2 (%)			
≥ 95	13 974 (79.2)	1605 (59.6)	
< 95	2523 (14.3)	470 (17.5)	
Missing	1116 (6.3)	617 (22.9)	< 0.0001
RR/min			
≤ 20	13 163 (74.6)	1329 (49.4)	
> 20	2995 (17.0)	393 (14.6)	
Missing	1478 (8.4)	970 (36.0)	< 0.0001
SBP (mmHg)			
≥ 120	13 974 (79.2)	1675 (62.2)	
91–119	2523 (14.3)	332 (12.3)	
≤ 90	356 (2.0)	100 (3.7)	
Missing	783 (4.5)	585 (21.7)	< 0.0001
HR/min			
< 90	9541 (54.1)	975 (36.2)	
≥ 90	7404 (42.0)	1140 (37.5)	
Missing	691 (3.9)	577 (21.4)	< 0.0001
GCS			
≥ 14	15 535 (88.1)	1859 (69.1)	
< 14	1444 (8.2)	623 (23.1)	
Missing	657 (3.7)	210 (7.8)	< 0.0001
Time of day			
Day	11 540 (65.4)	356 (13.2)	
Night	6068 (34.4)	204 (7.6)	
Missing	28 (0.2)	2132 (79.2)	< 0.0001
Weekday			
Monday–Thursday	10 034 (56.9)	1578 (58.6)	
Friday–Sunday	7602 (43.1)	1114 (41.4)	0.092

GCS, Glasgow Coma Score; HR, hazard ratio; MECU, mobile emergency care unit; OR, odds ratio; RR, relative risk; SBP, systolic blood pressure.

who do not fulfil the criteria for MECU involvement in the acute situation. Although patients in MECU and non-MECU transfers may show similar distributions of sex, age, clinical conditions, etc., they are likely to differ in the severity of disease or the ability to compensate for disease-related physical challenges. Some studies have shown that the presence of a physician in an ambulance can lead to increased survival [15,20]. We found a strong association between MECU and death, which, in reality, probably reflected the fact that MECUs are typically dispatched to patients with the most severe diseases and the highest risk of death.

Several potential, easily accessible risk factors have been mentioned in previous studies, including age, male sex, abnormal vital sign values, severe comorbidity and arrival at the ED during the night or on weekends [4,6,8,14,16]. The risk related to male sex might partly arise from the fact that men constitute the majority of individuals involved in traumas/injuries. However, medical emergency conditions typically constitute the vast majority of prehospital ambulance transfers [21]. Among patients who sustain traumas, a GCS of 14 or less was previously found to be a reliable marker for predicting hospital admission in the absence of other major risk indicators [22].

We did not find any associations related to time of day or week.

Strengths and limitations

The main strength of this study was the cohort, which included consecutive patients with acute conditions who arrived at the ED by ambulance. All patients had complete follow-up data, combined with data from national, validated registries, which were highly complete.

The patients in the study were unselected. When the ambulance arrived, patients of all categories were included, except those who required direct transfer to highly specialized units.

We analysed only factors accessible to prehospital healthcare personnel. Thus, the results were directly useful for individuals involved in the prehospital system and in the transitional phase, between prehospital transport and the ED.

Comorbidity was reported in terms of the Charlson Comorbidity Index on the basis of hospital discharge diagnoses within the last 10 years. We could not include patient diagnoses from primary care, which independently manages the early stages of several chronic diseases. Therefore, a comorbidity score of zero might not have truly indicated no comorbidity present; however, we chose to consider it a marker of no comorbidity, with the assumption that a diagnosed disease sufficiently severe to affect mortality would most likely appear in the hospital registries. A subanalysis of the association between severe comorbidity (Charlson Comorbidity Index >2) and 7-day mortality resulted in an OR of 1.5 (95% CI: 1.3–1.7). Information on comorbidity is not currently available in an electronic form in the prehospital system; however, it is often available from patient reports or relatives.

We defined threshold values for distinguishing dichotomous (normal vs. abnormal) vital sign parameters for respiratory rate, heart rate and GCS. Although continuous data might have shown a gradual decrease or increase in mortality, we chose to simplify the interpretation of the results by defining values that could be considered 'normal' within most acute paradigms.

It is a routine prehospital procedure to record patient characteristics and vital sign values at the beginning of each contact. Our collection of ambulance records for this study had a short run-in phase, from April to October 2012. After that, records were collected consistently for

Table 3 7-Day mortality odds ratios ($N = 20\,328$)

	7-Day mortality		Crude		Adjusted	
	n/n (%)	95% CI	OR	95% CI	OR	95% CI
Total	1080 (5.3)	5.0–5.6				
Ambulance						
No physician	665 (3.8)	3.5–4.0	1.0		1.0	
MECU	415 (15.4)	14.1–16.8	4.7	4.1–5.3	5.3	4.6–6.1
Sex						
Female	478	4.4–5.2	1.0		1.0	
Male	602	5.4–6.3	1.2	1.1–1.4	1.4	1.2–1.6
Age (years)						
18–29	18	0.4–1.1	1.0		1.0	
30–44	36	0.9–1.8	2.0	1.1–3.5	2.0	1.1–3.5
45–69	348	4.0–5.3	7.4	4.6–12.0	7.3	4.5–11.8
70–84	423	7.3–8.8	12.8	8.0–20.6	13.0	8.1–20.8
85–99	251	9.0–11.5	16.7	10.3–27.0	17.7	8.1–20.8
100	4	3.1–26.1	18.3	5.9–57.2	21.2	6.8–66.3
Charlson Comorbidity Index						
0	379	3.2–3.9	1.0		1.0	
1	190	4.3–5.7	1.4	1.2–1.7	1.0	0.8–1.1
2	511	8.0–9.5	2.6	2.3–3.0	1.5	1.3–1.7
Vital parameters						
SpO_2 (%)						
≥ 95	229	1.3–1.7	1.0		1.0	
< 95	310	7.8–9.7	6.2	5.2–7.3	4.3	3.6–5.1
Missing	541	29.0–33.5	29.3	24.9–34.6	32.0	27.0–38.0
RR/min						
≤ 20	281	1.7–2.2	1.0		1.0	
> 20	248	6.5–8.2	4.0	3.4–4.8	3.6	3.0–4.3
Missing	551	20.9–24.2	14.7	12.6–17.1	17.1	14.6–20.1
SBP (mmHg)						
≥ 120	378	2.2–2.7	1.0		1.0	
91/119	152	4.5–6.2	2.3	1.9–2.8	2.7	2.2–3.3
≤ 90	77	13.6–20.6	8.2	6.3–10.7	7.0	5.3–9.1
Missing	473	32.1–37.2	21.4	18.4–24.8	30.8	26.1–36.4
HR/min						
< 90	281	2.6–3.3	1.0		1.0	
≥ 90	333	4.0–5.0	1.5	1.3–1.7	1.7	1.4–2.0
Missing	466	63.8–70.9	21.2	18.0–24.9	31.2	26.1–37.4
GCS						
≥ 14	356	1.8–2.3	1.0		1.0	
< 14	548	24.6–28.5	17.3	15.0–19.9	17.0	14.7–19.7
Missing	176	17.7–23.1	12.2	10.0–14.8	12.2	10.0–15.0
Time of day						
Day	509	3.9–4.7	1.0		1.0	
Night	265	3.7–4.7	1.0	0.8–1.1	1.0–1.4	1.0–1.4
Missing	306	12.7–15.7	3.7	3.2–4.3	3.8–5.1	3.8–5.1
Weekday						
Monday–Thursday	626	5.0–5.8	1.0		1.0	
Friday–Sunday	454	4.8–5.7	1.0	0.9–1.1	1.0	0.9–1.14

Crude and adjusted for sex and age group.
CI, confidence interval; GCS, Glasgow Coma Score; HR, hazard ratio; MECU, mobile emergency care unit; OR, odds ratio; RR, relative risk; SBP, systolic blood pressure.

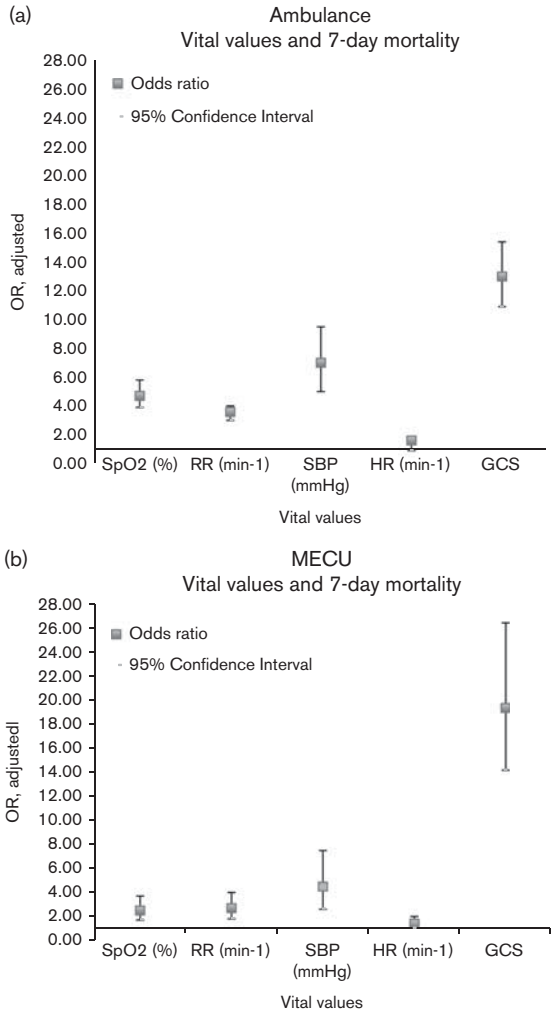
the rest of the study period. Sensitivity analyses showed no differences in ORs before and after the initial collection phase.

The results showed a close association between missing data and 7-day mortality. The MECU records were missing a relatively large amount of data and the missing values did not meet the assumption of missing at random. The mechanisms that lead to missing records in prehospital databases are probably because of the often hectic nature of emergency scenes. In the present study, we have chosen to be very open of the amount of missing data and to provide data that clearly demonstrate that these data are not missing at random. We believe that this is a strength in our study – but also acknowledge that results in our multivariate analysis suffer because of these missing data. In the multivariate analysis, we have handled missing values as independent variables. As OR related to missing values are very high, this results in a conservative OR estimate for patients with registered abnormal vital values closer to one than we believe it would have been if no data were missing.

Generalizability

The present single-centre study focused on an ED at a university hospital; interpretations may not be generalizable to other settings. However, our study cohort comprised unselected patients transported by ambulance to the ED because of medical, surgical and traumatic

Fig. 2



Odds ratios and confidence intervals. Adjusted for sex and age group. (a) Ambulance vital values and 7-day mortality. (b) MECU vital values and 7-day mortality. GCS, Glasgow Coma Score; HR, hazard ratio; MECU, mobile emergency care unit; OR, odds ratio; RR, relative risk; SBP, systolic blood pressure.

conditions. Thus, our results reflected a highly diverse patient group.

Conclusion

Among adult patients transferred by ambulance to the ED, the overall 7-day mortality was 5.3%, but differed in the two subgroups, with 15.4% in the MECU-assisted ambulance transfers and 3.8% in the non-MECU transfers.

Except for a slightly higher proportion of men among the MECU-transferred patients, patients showed similar distributions of age and clinical characteristics.

A high risk of short-term death was significantly associated with prehospital-recorded vital sign values beyond the normal reference limits, and in particular, a GCS below 14 (OR: 17). The strong association between missing data and mortality supports the notion that an automatic system should be implemented for recording and disseminating vital values from the prehospital system to the ED and might improve identification of patients at high risk and potentially prevent deterioration in the ED.

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C.N.B. conceived the study, analysed and interpreted the data, and drafted the manuscript. A.T.L. conceived and coordinated the study as well as performed critical appraisal of the manuscript. A.T.L., M.B. and S.M. contributed to writing, reviewing and revising the paper. All authors interpreted the data and critically reviewed drafts of the manuscript. All authors edited and approved the final manuscript.

Conflicts of interest

There are no conflicts of interest.

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