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Effect of emergency response team versus standard care for critically ill medical patients in the Emergency Department – a register based study

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TITLE PAGE

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Effect of emergency response team versus standard care for critically ill medical patients in the Emergency Department –a register based study

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Abstract

Aim: To investigate quality of care, resource use and patient outcome in management by emergency response team versus standard care for critically ill medical patients in the Emergency Department (ED).

Methods: Register-data from 2015 and 2016 on critically ill medical patients with National Early Warning Score 2 5-10 points were retrieved. Multivariate logistic regression was used to assess outcomes for quality of care, resource use and patient outcome.

Results: A total of 691 patients managed by emergency response team and 429 patients receiving standard care were included. Median age was 66 years, 53.5% were male, 44.3% were admitted to an intensive care unit (ICU) and mortality rate was 10.6%. Management by team had a positive association with 'complete set of vital signs' (OR 1.742, CI 1.273-2.384), 'analgesic within 20 minutes' (OR 3.306, CI 1.399-7.810) and 'antibiotic within 60 minutes if sepsis' (OR 7.553, CI 3.215-17.744), but a negative association with 'documentation of pain assessment' (OR 0.068, CI 0.037-0.128). Team management was also associated with 'critical care in ED' (OR 10.468, CI 7.553-14.506), 'ED length of stay (LOS) < 180 minutes' (OR 2.846, CI 2.009-4.032), 'ICU admittance' (OR 2.680, CI 1.907-3.766) and 'mortality' (OR 1.934, CI 1.175-3.186). It had a negative association with '> 3 diagnostic interventions' (OR 0.706, CI 0.514-0.970).

Conclusion: Management by team showed promising results in quality of care and resource use for critically ill medical patients in the ED. The results for later outcomes such as mortality, ICU LOS and hospital LOS were more ambiguous. We recommend future studies of management of this patient group, to ensure optimal and uniform care.

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ABSTRACT

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STRENGTHS AND LIMITATIONS OF THIS STUDY

- The use of register data made it possible to include a large group of patients
- Multivariate analysis allowed adjustment for several factors that could influence on the outcomes
- The observational nature of the study makes it difficult to draw conclusions about cause and effect of the two types of management under investigation
- The registers did not include data on all cofactors relevant for the outcomes far away in time from the ED stay
- The single-center design could limit representativeness

INTRODUCTION

The use of multidisciplinary emergency response teams has become more widespread over the last years, in a variety of settings and for different patient groups, also in the Emergency Department (ED). Trauma teams and cardiac arrest teams have existed for several decades.[1, 2] Teams for specific conditions such as myocardial infarction and stroke have become more common,[3, 4] as have the use of medical emergency teams or critical care outreach for deteriorating ward patients.[2, 5]

Management by emergency response teams have been found to have a promising effect on time to treatment, mortality and morbidity in specific conditions such as trauma, stroke, sepsis and ST-elevation myocardial infarction.[6-10] The effect on conditions with uncertain origin such as in deteriorating ward patients is more unclear.[11] The use of team could divert resources away from other patients and be time-consuming and expensive,[11] and needs to balance between over- and under-triage.

It is well known that critically ill patients in need of intensive care unit (ICU) admission could receive suboptimal care in the ED, and that prolonged ED length of stay (LOS) may cause sentinel events and even increase mortality.[12-14] Despite of this, and the knowledge about the positive effect of emergency response teams for other group of patients, few studies have investigated the use of emergency response teams for critically ill general medical patients in the ED. It has been found that although many EDs do not use such teams, management by team could ensure early diagnosis and treatment and a shorter ED LOS.[15-17]

In 2013 our hospital implemented an emergency response team for critically ill general medical patients in the ED, after several years with similar teams for trauma and cardiac arrest patients. In order to contribute to the knowledgebase about team for these patients in the ED setting, we aimed to investigate the use of team versus standard care for this patient group. The objectives were to investigate how management by team was associated with ED quality of care, ED resource use and patient outcome, compared to standard care.

METHODS

Study setting

This cohort study used register data from 2015 and 2016 from Oslo University Hospital (OUH) Ullevål, a tertiary hospital with all sub-specialties in internal medicine. The ED is considered large-volume with 28 000 patients in 2015 and an admittance rate of 90%. Half of the admitted patients were adult medical patients. In Norway self-admittance is rare, and patients are usually referred to the ED by primary care physicians or ambulance personnel by telephone before arrival. No emergency

medicine specialty existed at the time of the study, and patients were reviewed by on-call subspecialists (ie internal medicine, orthopedic, neurology etc) in the ED.

Participants and management

Triage 1 and 2 patients referred to the medical specialties were considered to be potentially critically ill and eligible for inclusion. Triage 1 patients were identified prior to arrival, at ED triage or later in the ED stay by using a single-parameter criteria system, hereafter called the OUH-criteria. They were managed in resuscitation rooms by a multidisciplinary team (table 1). The team was led by a registrar in internal medicine, and the patients were assessed and managed using an ABCDE-approach. Other medical patients, including triage 2, were triaged according to Manchester Triage System. Triage 2 patients were seen immediately by an ED nurse and within 10 minutes by a registrar in internal medicine, and thus received what is defined as standard care in this study. If needed, care was supplemented by additional ED nurses and/or physicians. Predefined pathways existed for patients with myocardial infarction, cardiac arrest or stroke, but some were managed as described above.

To reduce heterogeneity in acuity between the two groups, we only included patients with National Early Warning Score 2 (NEWS2) 5-10 points, excluding those missing 3 or more NEWS2 part-scores. A cut-off of ≥ 5 was chosen because of its increased risk of serious clinical outcome and recommendation as a threshold for urgent clinical review by a clinician or team.[18] A cut-off of ≤ 10 was chosen due to few triage 2 patients with higher scores and to avoid outliers that obviously were critically ill. We excluded patients under 18 years and those with the orders Not for resuscitation or Not for ICU decided in the ED (figure 1).

Table 1. OUH-criteria and members of emergency response team

OUH-criteria	**Team members**
Threatened airway	Registrar in internal medicine (team leader)
Respiratory arrest	Registrar in anesthesiology
Respiration rate < 8 or > 40*	ED nurses (3)
Oxygen saturation < 85 % *	Nurse anesthetist
Systolic blood pressure < 90 mmHg*	Phlebotomist
Pulse < 35 or > 130*	Radiographer
GCS < 9*	If needed supplemented by: Registrar in cardiology Registrar in neurology Registrar other subspecialty
Persistent/continuous fitting	
Temperature < 32*	
Clinical concern by prehospital personnel, ED doctor or ED nurse	

OUH: Oslo University Hospital, * vital sign criteria, GCS: Glasgow Coma Scale, ED: Emergency Department

Data sources

Data on triage 1 patients were retrieved from a quality register containing data from medical records on all medical triage 1 patients from 2015 and 2016, except 44 patients not holding a Norwegian social security number. Data on triage 2 patients were retrieved from a quality register with similar data on every 5th admitted medical triage 2 patients from the same time period.

Outcomes and variables

Quality of care was investigated using four outcomes: pain assessment documented,[19] analgesic given within 20 minutes,[20] complete set of vital signs documented,[21] and antibiotics within 60 minutes if sepsis.[22] Vital signs included respiration rate, SpO2, pulse, blood pressure, temperature and Glasgow Coma Scale.[21] Sepsis was defined as infection being the main discharge diagnosis and ≥ 2 qSOFA or ≥ 2 SIRS criteria present at arrival.

Resource use was investigated using three outcomes: > 3 diagnostic interventions, critical care in ED and ED length of stay (LOS) < 180 minutes. Diagnostic interventions was defined as electrocardiogram, arterial blood gas, blood culture, other microbiological investigation, lumbar puncture, chest x-ray, other x-ray, computed tomography (CT) of head, other CT, cardiac ultrasound or other ultrasound. Critical care in ED was defined as one or more of the following interventions or medications: intubation, other airway interventions, non-invasive ventilation, arterial line, central venous line, pacing, cardioversion, cardiopulmonary resuscitation, pleural catheter or administration of blood products, sedatives, anesthetic agents, antiarrhythmics or vasopressors.[23]

Four outcomes were used to investigate patient outcome: ICU admission, ICU LOS < 66 hours, hospital LOS < 194 hours, and mortality. ICU admission was defined as admission to any ICU in the hospital directly from the ED. Mortality was defined as mortality at 30 days or hospital mortality later than 30 days.

The cut-offs for ED, ICU and hospital LOS was made using the 75 percentiles. All outcome variables were dichotomous.

In multivariate analysis Charlson Comorbidity Index (CCI)[24] and history of substance abuse and/or psychiatric illness were used as comorbidity variables, the first was categorized as 0p, 1-2p, 3-4p and >4p,[25] the latter was dichotomous. NEWS2 was used as a dichotomous variable; NEWS2 5-6 points or 7-10 points.

Other variables included presenting complaint, which was grouped into categories based on frequency, and main discharge diagnoses which was grouped accordingly.

Statistical analysis

Analyses were performed using IBM SPSS® version 25.0 for Windows (Armonk, NY, USA). Continuous variables are presented as median with interquartile range (IQR) and categorical variables as number and percentage. Group-comparison used Mann-Whitney rank sum test for continuous and Chi-square test or exact test for categorical variables, and was two-sided.

Multivariate logistic regression was used to investigate association with the outcomes, and clinical rationale was used to build the models (supplement 1). For all outcomes we adjusted for gender, age, CCI, history of substance abuse and/or psychiatric history and NEWS2. For ICU admission and ICU LOS < 66 hours we also adjusted for critical care in ED. For the other outcomes, except critical care in ED, we adjusted for critical care in ED and/or ICU admission. Unadjusted and adjusted odds ratio (OR) with confidence intervals (CI), as well as p-values, are presented. The goodness of fit was assessed using Hosmer-Lemeshow test.

A p-value < 0.05 was regarded as statistically significant in all analysis.

Ethics and patient involvement

All data were register data from medical records, and treatment was not affected. Informed consent was therefore waived, and the study was approved by the Data Protection officer at OUH (2016/10319). Patients or the public were not involved in any phase of this study.

RESULTS

Patient characteristics

A total of 1120 patients, of which 691 (61.7%) were managed by team, met the inclusion criteria. Median age was 66 years, 599 (53.5%) were male, and respiratory (n=245, 22.4%) and infection (n=211, 19.3%) problems were the most common presenting complaints (table 2). Patients managed by the team were younger (p<0.001), more were male (p<0.05), and they had lower CCI but more history of substance abuse and/or psychiatric illness than those who received standard care (both p<0.001). More team patients also had OUH vital sign criteria present and NEWS2 7-10 points at arrival, and presenting complaint and discharge diagnoses differed between the two groups (all p<0.001), with acute poisoning being dominant for team patients and infection dominant for standard care patients.

Table 2. Patient characteristics

	Whole cohort (n=1120)	Team (n=691)	Standard (n=429)
Age, median (IQR)	66 (34)	60 (38)**	73 (23)
Male gender	599 (53.5%)	391 (56.6%)*	208 (48.5%)
Charlson Comorbidity Index (n=664+424)		**	
0p	413 (38.7%)	292 (45.3%)	121 (28.5%)
1-2p	469 (43.8%)	249 (38.7%)	219 (51.7%)
3-4p	131 (12.3%)	73 (11.3%)	58 (13.7%)
>4p	56 (5.2%)	30 (4.7%)	26 (6.1%)
History of substance abuse and/or	296 (26.4%)	238 (34.4%)**	58 (13.5%)

psychiatric illness			
Presenting complaint (n=689+407)		**	
Cardiac/circulatory	163 (14.9%)	79 (11.5%)	84 (20.6%)**
Acute poisoning	193 (17.6%)	174 (25.3%)	19 (4.7%)**
Respiratory	245 (22.4%)	147 (21.3%)	98 (24.1%)
Consciousness/neurologic	201 (18.3%)	183 (26.6%)	18 (4.4%)**
Abdominal	35 (3.2%)	29 (4.2%)	6 (1.5%)*
Infection	211 (19.3%)	60 (8.7%)	151 (37.1%)**
Other	48 (4.4%)	17 (2.5%)	31 (7.6%)**
OUH vital sign criteria present at arrival	435 (38.8%)	327 (47.3%)**	108 (25.2%)
NEWS2-score		**	
5	216 (19.3%)	102 (14.8%)	114 (26.6%)
6	248 (22.1%)	144 (20.8%)	104 (24.2%)
7	223 (19.9%)	128 (18.5%)	95 (22.1%)
8	184 (16.4%)	129 (18.7%)	55 (12.8%)
9	144 (12.9%)	105 (15.2%)	39 (9.1%)
10	105 (9.4%)	83 (12.0%)	22 (5.1%)
NEWS 7-10 points	656 (58.6%)	445 (64.4%)**	211 (49.2%)
Primary discharge diagnosis (n=690+428)		**	
Cardiac/circulatory	229 (20.5%)	131 (19.0%)	98 (22.9%)
Poisoning	214 (19.1%)	192 (27.8%)	22 (5.1%)
Respiratory	117 (10.5%)	70 (10.1%)	47 (11.0%)
Neurologic	57 (5.1%)	56 (8.1%)	1 (0.2%)
Abdominal	85 (7.6%)	42 (6.1%)	43 (10.0%)
Infection	309 (27.6%)	125 (18.1%)	184 (43.0%)
Others	107 (9.6%)	74 (10.7%)	33 (7.7%)

IQR: interquartile range, OUH: Oslo University Hospital, NEWS2: National early warning score 2, GCS: Glasgow coma scale, *p<0.05, **p<0.001

Quality of care

Pain assessment was documented for 132 (11.8%) patients and 720 (64.3%) had a complete set of vital signs documented (table 3). Of the 291 (26.0%) patients that were given analgesic, 69 (24.3%) received it within 20 minutes. A total of 86 (49.7%) of the sepsis patients that were given antibiotic received it within 60 minutes. In the univariate analysis significantly fewer team patients than those receiving standard care had pain assessment documented, but more had a complete set of vital signs documented at arrival (both p<0.001) (table 3). More also received analgesic within 20 minutes and antibiotic within 60 minutes if sepsis, and the median time to analgesic and antibiotic were shorter (all p<0.001).

Table 3. Quality of care, resource use and patient outcome – univariate analysis

	Whole cohort (n=1120)	Team (n=691)	Standard (n=429)
Quality of care			
Pain assessment documented	132 (11.8%)	15 (2.2%)**	117 (27.3%)

Complete set of vital signs at arrival	720 (64.3%)	474 (68.6%)**	246 (57.3%)
Analgesic given	291 (26.0%)	188 (27.2%)	103 (24.0%)
Min to analgesic, median (IQR) (n=184+100)	43 (53.5)	32 (66)**	63 (66)
Analgesic within 20 min (n=184+100)	69 (24.3%)	57 (31.0%)**	12 (12.0%)
Sepsis (Infection + ≥ 2 qSOFA or ≥ 2 SIRS)	268 (23.9%)	113 (16.4%)**	155 (36.1%)
Antibiotic given (n=113+155)	179 (66.8%)	75 (66.4%)	104 (67.1%)
Min to antibiotic, median (IQR) (n=74+99)	60 (81)	30.5 (31.8)**	94 (75)
Antibiotic within 60 min (n=74+99)	86 (49.7%)	59 (79.7%)**	27 (27.3%)
Resource use			
Diagnostic interventions		**	
0	8 (0.7%)	7 (1.0%)	1 (0.2%)
1	78 (7.0%)	47 (6.8%)	31 (7.2%)
2	161 (14.4%)	115 (16.6%)	46 (10.7%)
3	274 (24.5%)	197 (28.5%)	77 (17.9%)
4	276 (24.6%)	167 (24.2%)	109 (25.4%)
5	253 (22.6%)	120 (17.4%)	133 (31.0%)
>5	70 (6.3%)	38 (5.5%)	32 (7.5%)
Diagnostic interventions > 3	599 (53.5%)	325 (47.0%)**	247 (63.9%)
Critical care in ED, any	525 (46.9%)	461 (66.7%)**	64 (14.9%)
Interventions	411 (36.7%)	390 (56.4%)**	21 (4.9%)
Medications	294 (26.3%)	244 (35.3%)**	50 (11.7%)
Critical care in ED and/or ICU admittance	663 (59.2%)	551 (79.7%)**	112 (26.1%)
ED LOS			
median min (IQR)	116 (109)	91 (78)**	161 (111)
< 180 min	840 (75.0%)	586 (84.8%)**	254 (59.2%)
Patient Outcome			
ICU admittance	496 (44.3%)	416 (60.2%)**	80 (18.6%)
ICU LOS			
median hours (IQR) (n=416+80)	27.5 (52)	25.5 (50)*	42.5 (68)
< 66 hours (n=416+80)	369 (74.4%)	316 (76.0%)	53 (66.3%)
Hospital LOS			
median hours (IQR)	96 (169)	67 (174)**	125 (143)
< 194 hours	838 (74.8%)	525 (76.0%)	313 (73.0%)
Mortality at 30 days / hospital discharge	119 (10.6%)	79 (11.4%)	40 (9.3%)

min: minutes, IQR: interquartile range, ICU: intensive care unit, ED: emergency department, LOS: length of stay, *p<0.05, **p<0.001

In the multivariate analysis management by team continued to be associated with having a complete set of vital signs (OR 1.742, CI 1.273-2.384), less documentation of pain assessment (OR 0.068, CI 0.037-0.128), to receive analgesic within 20 minutes (OR 3.306, CI 1.399-7.810) and antibiotic within 60 minutes if sepsis (OR 7.553, CI 3.215-17.744) (table 4).

Table 4. Multivariate analysis of management by team versus standard care

Outcomes	**Crude OR (CI)**	**Adjusted OR (CI)**[1]
Quality of care		

Complete set of vital signs[a]	1.625 (1.266-2.086)**	1.742 (1.273-2.384)*
Pain assessment documented[a]	0.059 (0.034-0.103)**	0.068 (0.037-0.128)**
Analgesic within 20 minutes[a] (n=284)	3.291 (1.669-6.492)*	3.306 (1.399-7.810)*
Antibiotic within 60 minutes if sepsis[a] (n=173)	10.489 (5.111-21.525)**	7.553 (3.215-17.744)**
Resource use		
Diagnostic interventions > 3[a]	0.502 (0.392-0.643)**	0.706 (0.514-0.970)*
Critical care in ED	11.431 (8.391-15.572)**	10.468 (7.553-14.506)**
ED LOS < 180 minutes[b]	3.845 (2.897-5.104)**	2.846 (2.009-4.032)**
Patient outcome		
ICU admittance[a]	6.599 (4.954-8.791)**	2.680 (1.907-3.766)**
ICU LOS < 66 hours[a] (n=496)	1.610 (0.962-2.695)	1.393 (0.777-2.498)
Hospital LOS < 194 hours[b]	1.172 (0.890-1.544)	1.247 (0.875-1.777)
Mortality[b]	1.255 (0.841-1.875)	1.934 (1.175-3.186)*

OR: Odds ratio, CI: confidence interval, ED: emergency department, LOS: length of stay, ICU: intensive care unit, *p<0.05, **p<0.001, [1] all adjusted for age, gender, Charlson comorbidity score, substance abuse or psychiatric history and NEWS 7-10, [a] adjusted for critical care in ED, [b] adjusted for critical care in ED and/or ICU admission

Resource use

Critical care was given to 525 (46.9%) patients in the ED and 599 (53.5%) had > 3 diagnostic interventions (table 3). Significantly more team than standard care patients received critical care in ED in the univariate analysis, but fewer had > 3 diagnostic interventions (both p<0.001) (table 3). They had shorter median ED LOS than standard care patients, and more had ED LOS < 180 minutes (both p<0.001).

In the multivariate analysis management by team continued to be associated with less than three diagnostic interventions (OR 0.706, CI 0.514-0.970), with receiving critical care in ED (OR 10.468, CI 7.553-14.506) and having ED LOS < 180 minutes (OR 2.846, CI 2.009-4.032) (table 4).

Patient outcome

A total of 496 (44.3%) patients were admitted to ICU and 119 (10.6%) were dead at 30 days or hospital discharge. Significantly more team than standard care patients were admitted to ICU in univariate analysis (p<0.001) (table 3). They had shorter median ICU LOS (p<0.05) and hospital LOS (p<0.001) than standard care patients. There were no differences in ICU LOS < 66 hours, hospital LOS < 194 hours or mortality.

Management by team continued to be associated with being admitted to ICU (OR 2.680, CI 1.907-3.766) in multivariate analysis. It was also associated with mortality (OR 1.934, CI 1.175-3.186) (table 4). It had no association with ICU LOS < 67 hours or hospital LOS < 194 hours.

DISCUSSION

For quality of care, management by team was associated with complete set of vital signs, administration of analgesic within 20 minutes and antibiotics within 60 minutes if sepsis. It was negatively associated with documentation of pain assessment. For resource use, management by team was associated with receiving critical care in ED and having an ED LOS < 180 minutes. It was negatively associated with > 3 diagnostic interventions. For patient outcome, association was found with ICU admittance and mortality. No association was found for ICU LOS < 66 hours or hospital LOS < 194 hours.

Quality of care

The investigation of quality of care in EDs often focuses on process indicators. Many include time intervals such as length of stay, time to ED provider, time to analgesic, time to investigations and time to decisions and treatment.[19, 26, 27] Also percentage of patients with documented pain assessment is suggested,[19] as is having a full set of vital signs documented.[21]

We found few studies comparing effect of management by team on these processes for critically ill medical patients. One recent practice improvement study found that introduction of a team response to critically ill medical patients reduced the time of several ED processes, namely time to provider, laboratory, diagnostic imaging and admission.[17] We found that administration of analgesic within 20 minutes and antibiotic within 60 minutes if sepsis had better outcome by use of team compared to standard care. For sepsis patients a recent review found that management by a team improved sepsis resuscitation bundle, in which administration of antibiotics with 60 minutes was one major component.[10] This is consistent with our findings. Management by team has also been found to have a positive effect on door-to-needle time in patients with stroke and myocardial infarction,[7, 8] further supporting that team management is beneficial in reducing time-critical treatment.

Team management also had a positive association with documentation of a complete set of vital signs, which in other studies have been found to be incomplete in many ED patients.[28-30]

Documentation of pain assessment had poorer outcome for team patients compared to standard care patients. We adjusted for NEWS2-score which would include patients with decreased consciousness, one factor that could influence this documentation. The better outcome for standard care patients could be due to these patients being triaged using MTS, in which pain assessment is integrated.[31] It could also be that teams responding to alerts of critical patients focus on lifesaving interventions, at the expense of pain assessment. Documentation of pain assessment should nevertheless be an integrated part of any assessment of conscious patients, and a team should have the resources to do this alongside other interventions.

In a general patient population of critically ill as this, different diagnosis will require different treatment, of which only a few will be time-critical in the same way as for the abovementioned

patient groups. There is a need to develop quality indicators specific for critically ill general medical patients in the future.

Resource use

We found that resource use for diagnostic interventions were less when patients were managed by team compared to standard care. Others have found that team management of critically ill patients resulted in a median of eight interventions, but this included both diagnostic and treatment interventions.[16] The clinical expertise of the multidisciplinary team compared to health personnel giving standard care may lead to fewer diagnostic interventions in team patients. The shorter ED LOS of the team patients could have an impact on diagnostic interventions performed in the ED. We adjusted for NEWS2 and receiving critical care in the ED, thus patients not stable enough for radiological investigations should not be the reason for fewer diagnostic interventions.

Despite adjusting for several factors, also degree of illness by use of NEWS2, the odds for receiving critical care in the ED were more than 10 for the team patients compared to standard care patients. The presence of team members with critical care competencies could be a reason for this, as they might be better at identifying patients that need these interventions and have the skills to perform them. It could also be that when a team alert is used, the anticipation of team members is that the patient truly is critically ill. This could cause initiation of critical care interventions like arterial line insertion, also when this might not be necessary. It is also possible that an unknown factor, such as severity of the illness, not covered by adjusting factors such as NEWS2, was present in the team patients.

The shorter ED LOS when patients are managed by team or other specialized management is in line with other studies.[13, 17] Prolonged ED LOS are thought to impact on quality of initial care, and can thus cause prolonged ventilator time in the ICU and even increase mortality.[12] It seems logical that a multidisciplinary team with more people having better critical care competencies manages patients quicker and with higher quality than standard care management. We also believe that in our setting the reduced ED LOS is caused by the team leader being a medical registrar with easy access to medical ICU beds.

Patient outcome

The odds for ICU admission were higher for patients managed by team compared to those receiving standard care, despite adjusting for factors that could impact on ICU admission, such as higher NEWS2 and receiving critical care in the ED. This could be due to factors already discussed; the competencies of the team to identify patients in need of ICU admission could be better than that of those giving standard care. It could also be due to the team management itself; anticipation of the patient being critically ill due to the team alert, as well as easy access to ICU beds and willingness to increase level of care for team patients.

Management by team was associated with increased odds of mortality in the multivariate analysis. Mortality was a combination of mortality during hospital stay and 30 day mortality, and thus an

outcome quite far away in time from initial management in the ED. Outcomes far away in time from the stay in the ED when investigating management in the ED have been criticized, as later factors may influence outcome.[32]

The other factors far away in time from the ED stay; ICU LOS and hospital LOS, were not affected by team management in the multivariate analysis, despite median LOS being shorter in univariate analysis. We believe the reasons could be similar to those discussed for mortality.

Limitations

This study collected data from two quality registers, based on medical records. The registers had data mainly from management in the ED, and few data from the post ED period. This limited the analysis of long-term outcomes such as mortality, ICU LOS and hospital LOS. Influencing factors such as complications, adverse events or decisions regarding limitation of treatment taking place after the ED stay could not be adjusted for. This limitation in data does however mimic real life in ED management. It should be emphasized that ED management should be the best considering available data at the moment. As such, data on ED processes could be more interesting than long term outcomes on which several later factors may be influential. We have also previously suggested that later outcomes may be less relevant than outcomes close to the ED stay, and have recommended use of 24 or 48 hour mortality.[33]

The use of register data also limited the amount of quality indicators that could be investigated. One interesting indicator would have been patient satisfaction; this was not present in the registers. This could have been difficult to investigate also with other methods, due to the critical illness of the patients. Using data from registers did reduce selection bias and contributed to a high inclusion rate, as all triage 1 and every 5th triage 2 patients were included in the registers.

The observational nature of the study makes it difficult to draw conclusions about cause and effect of the two types of management under investigation. The use of multivariate analysis made it possible to investigate associations, which enhance the knowledgebase for the management of this patient group, and could be a starting point for future research. The study was also from a single ED, and may not be representative for other EDs.

We included patients with one or two missing NEWS2 part scores. Presence of the missing scores could have resulted in a NEWS2 higher than 10 points, the upper limit for inclusion. More triage 2 than triage 1 patients had missing NEWS2 part scores, and thus potentially higher NEWS2, so we do not believe inclusion of patients with missing part scores have impacted on the results

Considerations for future research

We recommend prospective interventional studies in the future, preferably multisite and international, to gain more knowledge about the best ED management of this, in our opinion, often downgraded patient group.

In addition, cost-analysis studies would give knowledge of other aspects of resource use than in the present study, and could inform ED and hospital managers in how to manage this patient group in a way that is high in quality without overusing resources.

CONCLUSION

We found that management by a multidisciplinary emergency response team had a positive association with several outcomes for quality of care; implying that quality is improved when critically ill medical patients is managed by the team compared to receiving standard care. Outcomes for resource use were ambiguous; team management was associated with less diagnostic interventions and shorter ED LOS, but with more critical care. For patients outcomes after the initial ED treatment the results were divergent; team management had no association with ICU LOS and hospital LOS, but was associated with increased mortality. It was also associated with ICU admission, an outcome closer in time.

As a starting point this observational study found promising results on managing critically ill medical patients with an emergency team rather than standard care. Further studies, preferably of prospective and interventional character, should be performed to investigate the most optimal and cost-effective management of this patient group in the future.

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Credit author statement

Stine Engebretsen: Conceptualization, Methodology, Formal analysis, Writing – original draft

Dag Jacobsen: Conceptualization, Methodology, Writing – review and editing, Supervision

Stig Tore Bogstrand: Conceptualization, Methodology, Writing – review and editing, Supervision

Rune Rimstad: Conceptualization, Methodology, Writing – review and editing, Supervision, Project administration

Conflict of interest

None

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Data sharing statement

The dataset analyzed during the current study are not publicly available due to restrictions from the Data Protection Officer at OUH.

Competing interests

The authors declare that they have no competing interests.

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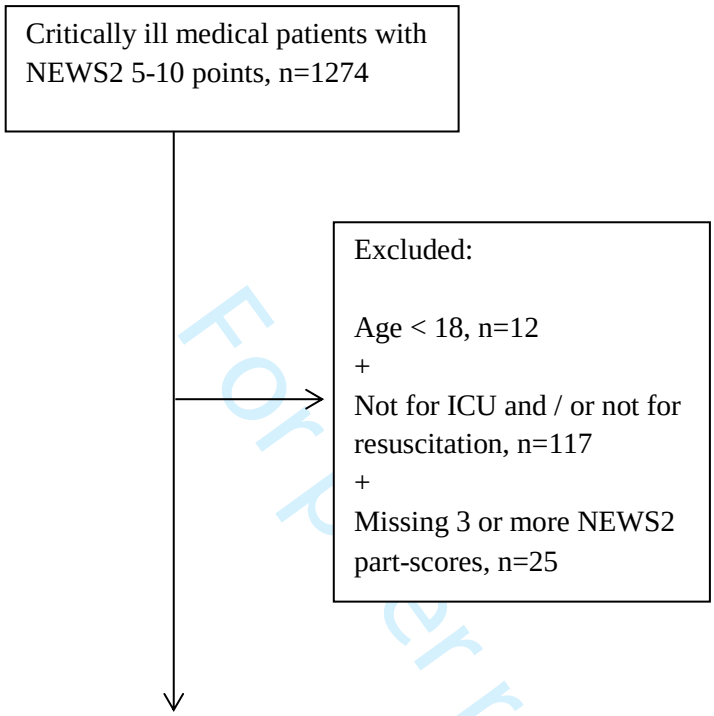
LEGENDS TO FIGURES

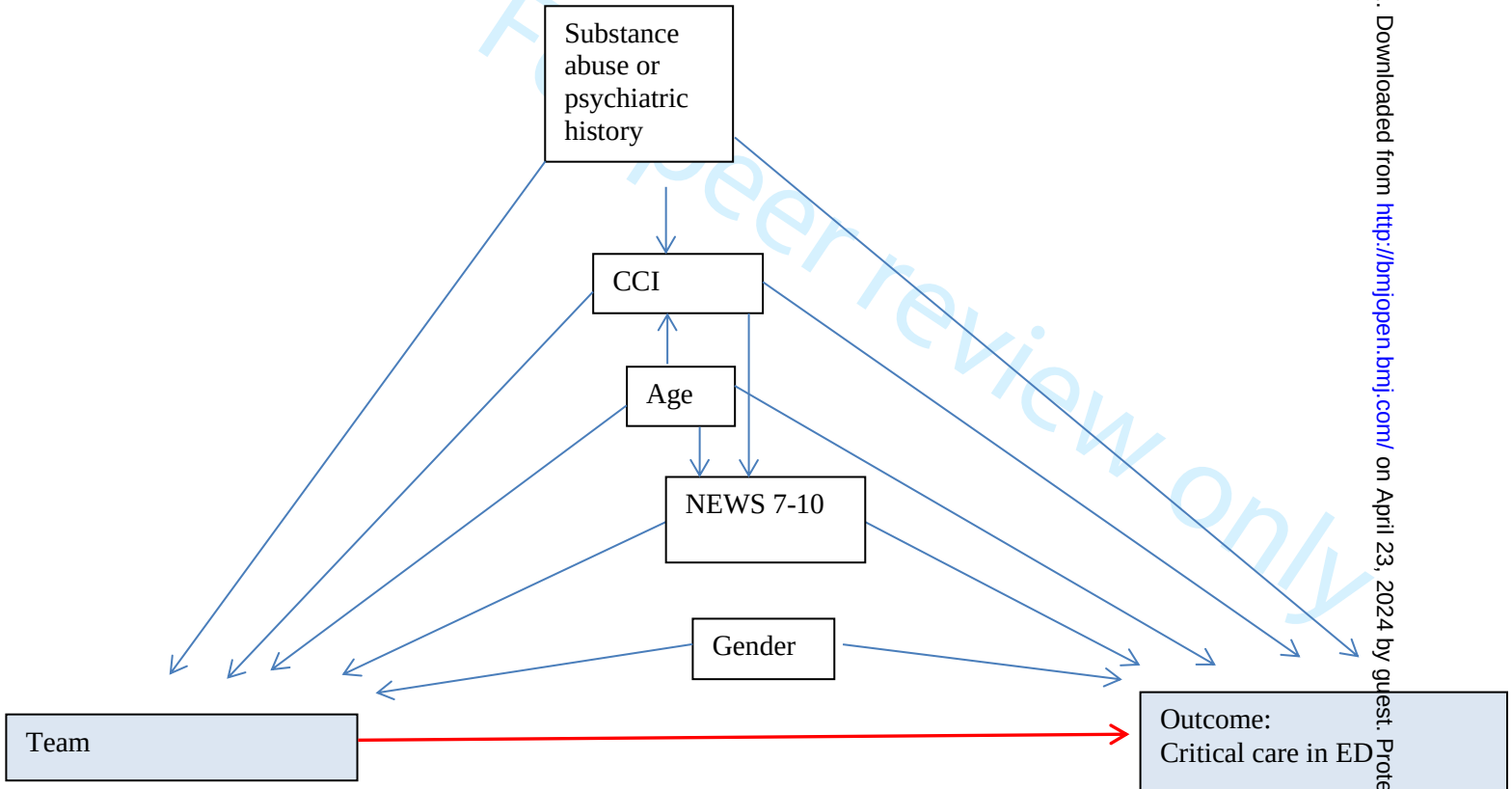
Figure 1: Flowchart of included and excluded patients

Figure 1

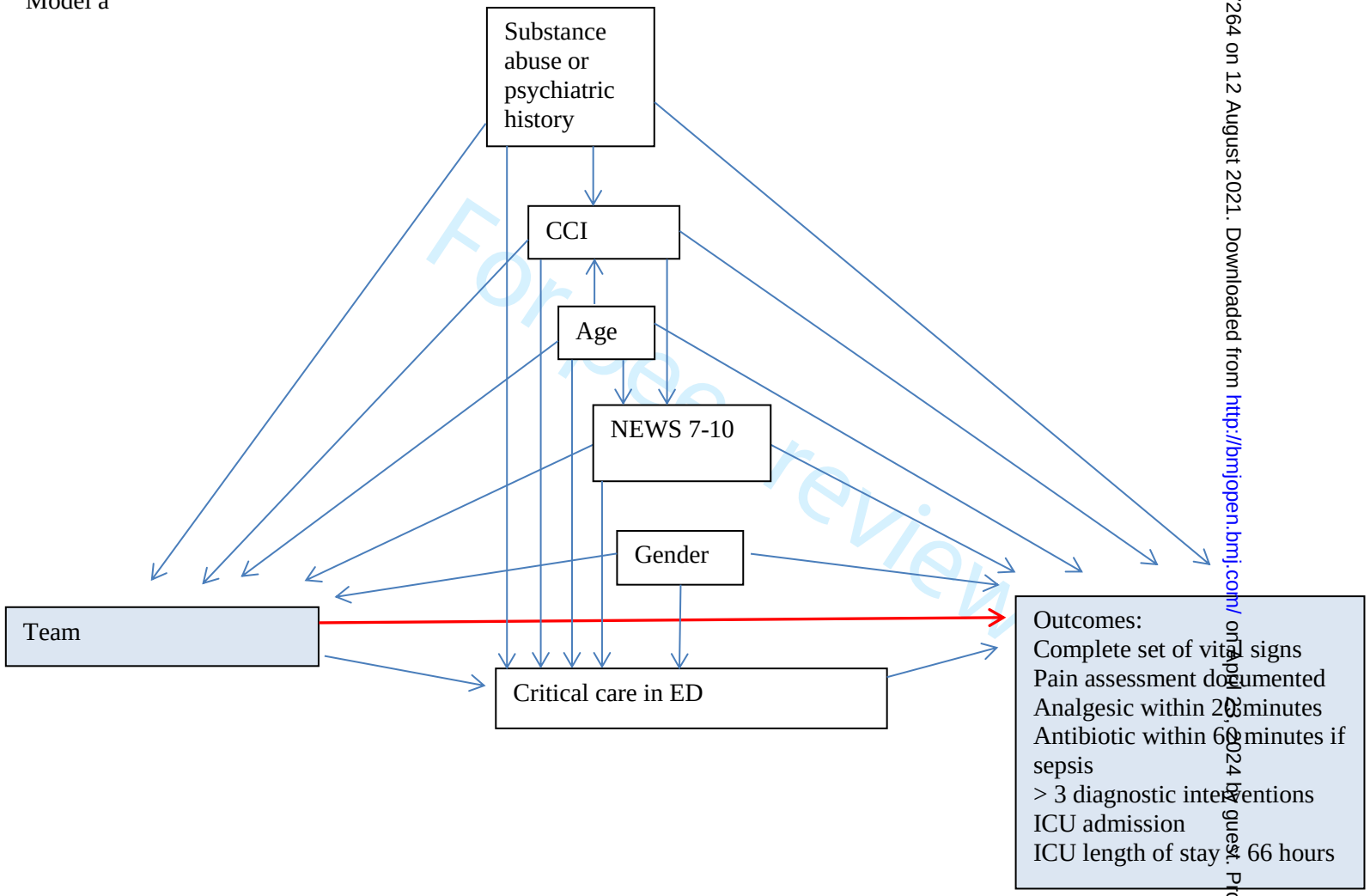


Multivariate logistic regression models

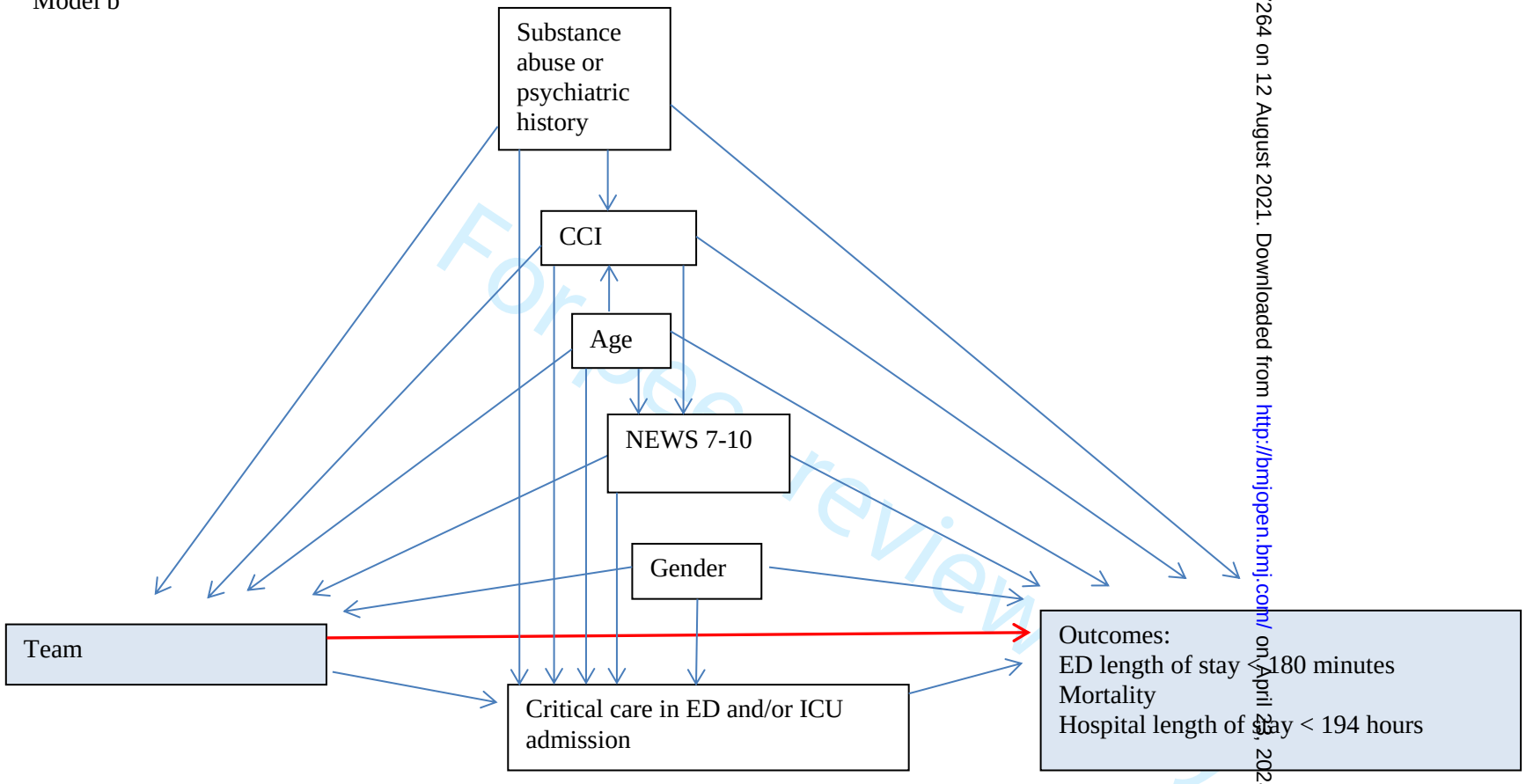
Model 1



Model a



Model b



Legend: Red arrow: timeline from management at arrival to outcome (blue boxes). White boxes: Factors potentially influencing management or outcome. Blue arrows: direction of influence.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-5
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5-8, table 4
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Quality of care, resource use and patient outcome by use of emergency response team compared to standard care for critically ill medical patients in the Emergency Department: A retrospective single-center cohort study from Norway

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TITLE PAGE

Title

Quality of care, resource use and patient outcome by use of emergency response team compared to standard care for critically ill medical patients in the Emergency Department: A retrospective single-center cohort study from Norway.

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ABSTRACT

Aim: To investigate quality of care, resource use and patient outcome in management by an emergency response team versus standard care for critically ill medical patients in the Emergency Department (ED). The emergency response team was multidisciplinary and had eight members, with a registrar in internal medicine as team leader.

Methods: Register-data from 2015 and 2016 on critically ill medical patients with National Early Warning Score 2 5-10 points were retrieved. Multivariate logistic regression was used to assess outcomes for quality of care, resource use and patient outcome.

Results: A total of 691 patients managed by emergency response team and 429 patients receiving standard care were included. Median age was 66 years, 53.5% were male, 44.3% were admitted to an intensive care unit (ICU) and mortality rate was 10.6%. Management by team had a positive association with 'complete set of vital signs' (OR 1.720, CI 1.254-2.360), 'analgesic within 20 minutes' (OR 3.268, CI 1.375-7.767) and 'antibiotic within 60 minutes if sepsis' (OR 7.880, CI 3.322-18.691), but a negative association with 'documentation of pain assessment' (OR0.068, CI 0.037-0.128). Team management was also associated with 'critical care in ED' (OR9.900, OR 7.127-13.751), 'ED length of stay (LOS) < 180 minutes' (OR2.944, CI 2.070-4.187), 'ICU admittance' (OR2.763, OR 1.962-3.891) and 'mortality' (OR1.882, CI 1.142-3.102).

Conclusion: Management by team showed positive results for quality of care and resource use for critically ill medical patients in the ED. The results for later outcomes such as mortality, ICU LOS and hospital LOS were more ambiguous. We recommend future studies of management of this patient group, to ensure optimal and uniform care.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The use of register data made it possible to include a large group of patients
- Multivariate analysis allowed adjustment for several factors that could influence on the outcomes
- The observational nature of the study makes it difficult to draw conclusions about cause and effect of the two types of management under investigation
- The registers did not include data on all cofactors relevant for late outcomes
- The single-center design could limit representativeness

INTRODUCTION

The use of multidisciplinary emergency response teams has become more widespread over the last years, in a variety of settings and for different patient groups, also in the Emergency Department (ED). Trauma teams and cardiac arrest teams have existed for several decades.[1, 2] Teams for specific conditions such as myocardial infarction and stroke have become more common,[3, 4] as have the use of medical emergency teams or critical care outreach for deteriorating ward patients.[2, 5]

Management by emergency response teams have promising effects on time to treatment, mortality and morbidity in specific conditions such as trauma, stroke, sepsis and ST-elevation myocardial infarction.[6-10] The effect on more undifferentiated conditions such as in deteriorating ward patients is more unclear.[11] The use of team could divert resources away from other patients and be time-consuming and expensive,[11] and it is therefore important to correctly identify which patients benefit from it.

It is well known that critically ill patients in need of intensive care unit (ICU) admission could receive suboptimal care in the ED, and that prolonged ED length of stay (LOS) may cause sentinel events and even increase mortality.[12-14] Despite this, and the knowledge about the positive effect of emergency response teams for other patient groups, only a few studies have investigated the use of emergency response teams for critically ill general medical patients in the ED. These studies found that although many EDs do not use such teams, team management could ensure early diagnosis and treatment and a shorter ED LOS.[15-17]

In 2013 our hospital implemented an emergency response team for critically ill general medical patients in the ED, after several years with similar teams for trauma and cardiac arrest patients. In order to contribute to the knowledgebase about team management of these patients in the ED setting, we aimed to investigate the use of team versus standard care for this patient group. The objectives were to investigate how management by team was associated with ED quality of care, ED resource use and patient outcome, compared to standard care.

METHODS

Study setting

This retrospective single-center cohort study used register data from 2015 and 2016 from Oslo University Hospital (OUH) Ullevål, a tertiary hospital with all sub-specialties in internal medicine. The ED is considered large-volume with 28 000 patients in 2015 and an admittance rate of 90%. Half of the admitted patients were adult medical patients. In Norway self-referral is rare. Patients are usually referred to the ED by primary care physicians or ambulance personnel by telephone before arrival. No emergency medicine specialty existed at the time of the study, and patients were reviewed in the

ED by on-call specialists (in internal medicine, orthopedic, neurology etc) appropriate to their presenting complaint.

In addition to an emergency response team for critically ill medical patients, the ED also had teams for trauma patients, cardiac arrest patients, critically ill children, patients with ST-elevation myocardial infarction and for patients with stroke considered for thrombolysis, the latter from 2016.

All team patients were categorized as triage 1. All other patients were triaged according to Manchester Triage System. Triage was an ongoing process, and all patients could be assigned a different triage category later in the ED stay than at arrival if their condition changed. This included alerting the relevant emergency response team if criteria was present. No rapid response team existed in the hospital or in the ED.

Participants and management

Triage 1 and 2 patients referred to the medical specialties were considered to be potentially critically ill and eligible for inclusion. Triage 1 patients were mostly identified prior to arrival or at ED triage by using a single-parameter criteria system, hereafter called the OUH-criteria. They were managed in resuscitation rooms by a multidisciplinary team (table 1). The team was led by a registrar in internal medicine, and the patients were assessed and managed using an ABCDE-approach. Triage 2 patients were seen immediately by an ED nurse and within 10 minutes by a registrar in internal medicine, and thus received what is defined as standard care in this study. If needed, care was supplemented by additional ED nurses and/or physicians.

To reduce heterogeneity in acuity between the two groups, we only included patients with National Early Warning Score 2 (NEWS2) 5-10 points, excluding those missing 3 or more NEWS2 part-scores. A cut-off of ≥ 5 was chosen because of its increased risk of serious clinical outcome and recommendation as a threshold for urgent clinical review by a clinician or team.[18] A cut-off of ≤ 10 was chosen due to few triage 2 patients with higher scores and to avoid outliers that obviously were critically ill. We excluded patients under 18 years and those with the orders Not for resuscitation or Not for ICU given in the ED (figure 1).

Table 1. OUH-criteria and members of emergency response team

OUH-criteria	**Team members**
Threatened airway	Registrar in internal medicine (team leader)
Respiratory arrest	Registrar in anesthesiology
Respiration rate < 8 or > 40*	ED nurses (3)
Oxygen saturation < 85 % *	Nurse anesthetist
Systolic blood pressure < 90 mmHg*	Phlebotomist
Pulse < 35 or > 130*	Radiographer
GCS < 9*	If needed supplemented by: Registrar in cardiology Registrar in neurology
Persistent/continuous fitting	
Temperature < 32*	

Clinical concern by prehospital personnel, ED doctor or ED nurse	Registrar other subspecialty

OUH: Oslo University Hospital, * vital sign criteria, GCS: Glasgow Coma Scale, ED: Emergency Department

Data sources and sample size

Data on triage 1 patients were retrieved from a quality register containing data from medical records on all medical triage 1 patients from 2015 and 2016, except 44 patients not holding a Norwegian social security number (n=1294). Data on triage 2 patients were retrieved from a quality register containing similar data on every 5th admitted medical triage 2 patient from the same time period (n=1426). In the latter register every 5th arriving patient had been chosen in order to get a similar amount of patients as in the register for triage 1 patients, and to get a spread in time of day, week and year.

Sample size was a pragmatic choice and not calculated, as inclusion was limited to eligible patients from the registers. By applying the rule of ten,[19] the sample size was considered sufficient for the analyses chosen.

Outcomes and variables

Quality of care was investigated using four outcomes: pain assessment documented,[20] analgesic given within 20 minutes,[21] complete set of vital signs documented,[22] and antibiotics within 60 minutes if sepsis.[23] Vital signs included respiration rate, SpO2, pulse, blood pressure, temperature and Glasgow Coma Scale.[22] Sepsis was defined as infection being the main discharge diagnosis and ≥ 2 qSOFA or ≥ 2 SIRS criteria present at arrival, thus covering both current diagnostic criteria and those used in the study period.[24]

Resource use was investigated using three outcomes: > 3 diagnostic interventions, critical care in ED and ED length of stay (LOS) < 180 minutes. Diagnostic interventions was defined as electrocardiogram, arterial blood gas, blood culture, other microbiological investigation, lumbar puncture, chest x-ray, other x-ray, computed tomography (CT) of head, other CT, cardiac ultrasound or other ultrasound. Critical care in ED was defined as one or more of the following interventions or medications: intubation, other airway interventions, non-invasive ventilation, arterial line, central venous line, pacing, cardioversion, cardiopulmonary resuscitation, pleural catheter or administration of blood products, sedatives, anesthetic agents, antiarrhythmics or vasopressors.[25]

Four outcomes were used to investigate patient outcome: ICU admission, ICU LOS < 66 hours, hospital LOS < 194 hours, and mortality. ICU admission was defined as admission to any ICU in the hospital directly from the ED. Mortality was defined as mortality at 30 days or hospital mortality later than 30 days.

The cut-offs for ED, ICU and hospital LOS was made using the 75 percentiles. All outcome variables were dichotomous.

In multivariate analysis Charlson Comorbidity Index (CCI)[26] and history of substance abuse and/or psychiatric illness were used as comorbidity variables, the first was categorized as 0p, 1-2p, 3-4p and >4p,[27] the latter was dichotomous. The variable 'deranged vital signs' was defined as Glasgow Coma Scale (GCS) <15 or NEWS 7-10 or OUH-criteria at arrival, and was dichotomous.

Other variables included presenting complaint, which was grouped into categories based on frequency, and main discharge diagnoses which was grouped accordingly.

Statistical analysis

Analyses were performed using IBM SPSS® version 25.0 for Windows (Armonk, NY, USA). Continuous variables are presented as median with interquartile range (IQR) and categorical variables as number and percentage. Separate n's are reported for variables with missing items from the registers. Group-comparison used Mann-Whitney rank sum test for continuous and Chi-square test or exact test for categorical variables, and was two-sided.

Multivariate logistic regression was used to investigate association with the outcomes, and clinical rationale was used to build the models (supplement 1). For all outcomes we adjusted for gender, age, CCI, history of substance abuse and/or psychiatric history and deranged vital signs. For complete set of vital signs, pain assessment documented, analgesic within 20 minutes, antibiotics within 60 minutes if sepsis, > 3 diagnostic interventions, ICU admission and ICU LOS < 66 hours we also adjusted for critical care in ED. For the other outcomes, except critical care in ED, we adjusted for critical care in ED and/or ICU admission. Unadjusted and adjusted odds ratio (OR) with confidence intervals (CI), as well as p-values, are presented. The goodness of fit was assessed using Hosmer-Lemeshow test.

A p-value < 0.05 was regarded as statistically significant in all analysis.

Ethics and patient involvement

All data were register data extracted from medical records, and treatment was not affected. Informed consent was therefore waived, and the study was approved by the Data Protection officer at OUH (2016/10319). Patients or the public were not involved in any phase of this study.

RESULTS

Patient characteristics

A total of 1120 patients, of which 691 (61.7%) were managed by team, met the inclusion criteria. Median age was 66 years, 599 (53.5%) were male, and respiratory (n=245, 22.4%) and infection (n=211, 19.3%) problems were the most common presenting complaints (table 2). Patients managed by the team were younger (p<0.001), more were male (p<0.05), and they had lower CCI but more

history of substance abuse and/or psychiatric illness than those who received standard care (both p<0.001). More team patients also had OUH vital sign criteria present,NEWS2 7-10 points, decreased GCS and deranged vital signs (all p<0.001). Presenting complaint and discharge diagnoses differed between the two groups (both p<0.001), with acute poisoning being dominant for team patients and infection dominant for standard care patients.

Table 2. Patient characteristics

	Whole cohort (n=1120)	Team (n=691)	Standard (n=429)
Age, median (IQR)	66 (34)	60 (38)**	73 (23)
Male gender	599 (53.5%)	391 (56.6%)*	208 (48.5%)
Charlson Comorbidity Index (n=664+424)		**	
0p	413 (38.7%)	292 (45.3%)	121 (28.5%)
1-2p	469 (43.8%)	249 (38.7%)	219 (51.7%)
3-4p	131 (12.3%)	73 (11.3%)	58 (13.7%)
>4p	56 (5.2%)	30 (4.7%)	26 (6.1%)
History of substance abuse and/or psychiatric illness	296 (26.4%)	238 (34.4%)**	58 (13.5%)
Presenting complaint (n=689+407)		**	
Cardiac/circulatory	163 (14.9%)	79 (11.5%)	84 (20.6%)**
Acute poisoning	193 (17.6%)	174 (25.3%)	19 (4.7%)**
Respiratory	245 (22.4%)	147 (21.3%)	98 (24.1%)
Consciousness/neurologic	201 (18.3%)	183 (26.6%)	18 (4.4%)**
Abdominal	35 (3.2%)	29 (4.2%)	6 (1.5%)*
Infection	211 (19.3%)	60 (8.7%)	151 (37.1%)**
Other	48 (4.4%)	17 (2.5%)	31 (7.6%)**
OUH vital sign criteria present at arrival	435 (38.8%)	327 (47.3%)**	108 (25.2%)
NEWS2-score		**	
5	216 (19.3%)	102 (14.8%)	114 (26.6%)
6	248 (22.1%)	144 (20.8%)	104 (24.2%)
7	223 (19.9%)	128 (18.5%)	95 (22.1%)
8	184 (16.4%)	129 (18.7%)	55 (12.8%)
9	144 (12.9%)	105 (15.2%)	39 (9.1%)
10	105 (9.4%)	83 (12.0%)	22 (5.1%)
NEWS2 7-10 points	656 (58.6%)	445 (64.4%)**	211 (49.2%)
GCS (n=565+280)		**	
13-15	554 (65.6%)	295 (52.2%)	259 (92.5%)
9-12	84 (9.9%)	71 (12.6%)	13 (4.6%)
<9	207 (24.5%)	199 (35.2%)	8 (2.9%)
Deranged vital signs (NEWS 7-10 or GCS<15 or OUH criteria)	873 (77.9%)	604 (87.4%)**	269 (62.7%)
Primary discharge diagnosis (n=690+428)		**	
Cardiac/circulatory	229 (20.5%)	131 (19.0%)	98 (22.9%)
Poisoning	214 (19.1%)	192 (27.8%)	22 (5.1%)
Respiratory	117 (10.5%)	70 (10.1%)	47 (11.0%)
Neurologic	57 (5.1%)	56 (8.1%)	1 (0.2%)
Abdominal	85 (7.6%)	42 (6.1%)	43 (10.0%)
Infection	309 (27.6%)	125 (18.1%)	184 (43.0%)

Others	107 (9.6%)	74 (10.7%)	33 (7.7%)

IQR: interquartile range, OUH: Oslo University Hospital, NEWS2: National early warning score 2, GCS: Glasgow coma scale, *p<0.05, **p<0.001

Quality of care

Pain assessment was documented for 132 (11.8%) patients, and for 720 (64.3%) a complete set of vital signs were documented (table 3). Of the 291 (26.0%) patients receiving analgesic, 69 (24.3%) received it within 20 minutes. Antibiotic treatment was started within 60 minutes to a total of 86 (49.7%) sepsis patients . In univariate analyses significantly fewer team than standard care patients had pain assessment documented, but more had a complete set of vital signs documented at arrival (both p<0.001) (table 3). More also received analgesic within 20 minutes and antibiotic within 60 minutes if sepsis, and the median time to analgesic and antibiotic were shorter (all p<0.001).

Table 3. Quality of care, resource use and patient outcome – univariate analysis

	Whole cohort (n=1120)	Team (n=691)	Standard (n=429)
Quality of care			
Pain assessment documented	132 (11.8%)	15 (2.2%)**	117 (27.3%)
Complete set of vital signs at arrival	720 (64.3%)	474 (68.6%)**	246 (57.3%)
Analgesic given	291 (26.0%)	188 (27.2%)	103 (24.0%)
Min to analgesic, median (IQR) (n=184+100)	43 (53.5)	32 (66)**	63 (66)
Analgesic within 20 min (n=184+100)	69 (24.3%)	57 (31.0%)**	12 (12.0%)
Sepsis (Infection + ≥ 2 qSOFA or ≥ 2 SIRS)	268 (23.9%)	113 (16.4%)**	155 (36.1%)
Antibiotic given (n=113+155)	179 (66.8%)	75 (66.4%)	104 (67.1%)
Min to antibiotic, median (IQR) (n=74+99)	60 (81)	30.5 (31.8)**	94 (75)
Antibiotic within 60 min (n=74+99)	86 (49.7%)	59 (79.7%)**	27 (27.3%)
Resource use			
Diagnostic interventions		**	
0	8 (0.7%)	7 (1.0%)	1 (0.2%)
1	78 (7.0%)	47 (6.8%)	31 (7.2%)
2	161 (14.4%)	115 (16.6%)	46 (10.7%)
3	274 (24.5%)	197 (28.5%)	77 (17.9%)
4	276 (24.6%)	167 (24.2%)	109 (25.4%)
5	253 (22.6%)	120 (17.4%)	133 (31.0%)
>5	70 (6.3%)	38 (5.5%)	32 (7.5%)
Diagnostic interventions > 3	599 (53.5%)	325 (47.0%)**	247 (63.9%)
Critical care in ED, any	525 (46.9%)	461 (66.7%)**	64 (14.9%)
Interventions	411 (36.7%)	390 (56.4%)**	21 (4.9%)
Medications	294 (26.3%)	244 (35.3%)**	50 (11.7%)
Critical care in ED and/or ICU admittance	663 (59.2%)	551 (79.7%)**	112 (26.1%)
ED LOS			
median min (IQR)	116 (109)	91 (78)**	161 (111)
< 180 min	840 (75.0%)	586 (84.8%)**	254 (59.2%)

Patient Outcome			
ICU admittance	496 (44.3%)	416 (60.2%)**	80 (18.6%)
ICU LOS median hours (IQR) (n=416+80) < 66 hours (n=416+80)	 27.5 (52) 369 (74.4%)	 25.5 (50)* 316 (76.0%)	 42.5 (68) 53 (66.3%)
Hospital LOS median hours (IQR) < 194 hours	 96 (169) 838 (74.8%)	 67 (174)** 525 (76.0%)	 125 (143) 313 (73.0%)
Mortality at 30 days / hospital discharge	119 (10.6%)	79 (11.4%)	40 (9.3%)

min: minutes, IQR: interquartile range, ICU: intensive care unit, ED: emergency department, LOS: length of stay, *p<0.05, **p<0.001

In multivariate analyses team management continued to be associated with having a complete set of vital signs (OR 1.720, CI 1.254-2.360), less documentation of pain assessment (OR 0.068, CI 0.037-0.128), to receive analgesic within 20 minutes (OR 3.268, CI 1.375-7.767) and antibiotic within 60 minutes if sepsis (OR 7.880, CI 3.322-18.691) (table 4).

Table 4. Multivariate analyses of team management versus standard care (n=1068 unless otherwise stated)

Outcomes	**Crude OR (CI)**	**Adjusted OR (CI)**[1]
Quality of care		
Complete set of vital signs[a]	1.625 (1.266-2.086)**	1.720 (1.254-2.360)*
Pain assessment documented[a]	0.059 (0.034-0.103)**	0.068 (0.037-0.128)**
Analgesic within 20 minutes[a] (n=272)	3.291 (1.669-6.492)*	3.268 (1.375-7.767)*
Antibiotic within 60 minutes if sepsis[a] (n=170)	10.489 (5.111-21.525)**	7.880 (3.322-18.691)**
Resource use		
Diagnostic interventions > 3[a]	0.502 (0.392-0.643)**	0.749 (0.545-1.030)
Critical care in ED	11.431 (8.391-15.572)**	9.900 (7.127-13.751)**
ED LOS < 180 minutes[b]	3.845 (2.897-5.104)**	2.944 (2.070-4.187)**
Patient outcome		
ICU admittance[a]	6.599 (4.954-8.791)**	2.763 (1.962-3.891)**
ICU LOS < 66 hours[a] (n=464)	1.610 (0.962-2.695)	1.374 (0.764-2.472)
Hospital LOS < 194 hours[b]	1.172 (0.890-1.544)	1.194 (0.837-1.703)
Mortality[b]	1.255 (0.841-1.875)	1.882 (1.142-3.102)*

OR: Odds ratio, CI: confidence interval, ED: emergency department, LOS: length of stay, ICU: intensive care unit, *p<0.05, **p<0.001, [1] all adjusted for age, gender, Charlson comorbidity score, substance abuse or psychiatric history and deranged vital signs, [a] adjusted for critical care in ED, [b] adjusted for critical care in ED and/or ICU admission

Resource use

Critical care was given to 525 (46.9%) patients in the ED and 599 (53.5%) had > 3 diagnostic interventions (table 3). Significantly more team than standard care patients received critical care in

ED in univariate analyses, but fewer had > 3 diagnostic interventions (both p<0.001) (table 3). They had shorter median ED LOS than standard care patients, and more had ED LOS < 180 minutes (both p<0.001).

In multivariate analyses management by team continued to be associated with receiving critical care in ED (OR 9.900, CI 7.127-13.751) and a ED LOS < 180 minutes (OR 2.944, CI 2.070-4.187) (table 4).

Patient outcome

A total of 496 (44.3%) patients were admitted to ICU and 119 (10.6%) were dead at 30 days or hospital discharge. Significantly more team than standard care patients were admitted to ICU in univariate analyses (p<0.001) (table 3). They had shorter median ICU LOS (p<0.05) and hospital LOS (p<0.001) than standard care patients. There were no differences in ICU LOS < 66 hours, hospital LOS < 194 hours or mortality.

Management by team continued to be associated with being admitted to ICU (OR 2.763, CI 1.962-3.891) in multivariate analyses. It was also associated with mortality (OR1.882, CI 1.142-3.102) (table 4). No association was found with ICU LOS < 67 hours or hospital LOS < 194 hours.

DISCUSSION

For quality of care, management by team was associated with complete set of vital signs, administration of analgesic within 20 minutes and antibiotics within 60 minutes if sepsis. It was negatively associated with documentation of pain assessment. For resource use, management by team was associated with receiving critical care in ED and an ED LOS < 180 minutes. For patient outcome, association was found with ICU admittance and mortality. No association was found with ICU LOS < 66 hours or hospital LOS < 194 hours.

Quality of care

The investigation of quality of care in EDs often focuses on process indicators. Suggested indicators include time intervals such as length of stay, time to ED provider, time to analgesic, time to investigations and time to decisions and treatment.[20, 28, 29] Also percentage of patients with documented pain assessment is suggested,[20] as is having a full set of vital signs documented.[22]

We found few studies comparing effect of management by team on these processes for critically ill medical patients. One recent practice improvement study found that introduction of a team response to critically ill medical patients reduced the time of several ED processes, namely time to provider, laboratory, diagnostic imaging and admission.[17] We found that administration of analgesic within 20 minutes and antibiotic within 60 minutes if sepsis had better outcome by use of

team compared to standard care. For sepsis patients a recent review found that management by a team improved sepsis resuscitation bundle, in which administration of antibiotics with 60 minutes is a major component.[10] This is consistent with our findings. Management by team is found to have a positive effect on door-to-needle time in patients with stroke and myocardial infarction,[7, 8] further supporting that team management is beneficial in reducing time-critical treatment.

Team management also had a positive association with documentation of a complete set of vital signs, which other studies have found to be incomplete in many ED patients.[30-32] Less documentation of vital signs at arrival in the standard care group is surprising, as local guidelines mandates vital signs to be documented at triage and throughout the ED stay. An Australian study found that the vital sign most commonly missing in ED documentation was GCS, [30] which in our study is missing more frequently for standard care than team patients. A reason for this could be that nurses tend to omit documentation of GCS when the patient is awake and alert, while it is considered more important to document if decreased. GCS is also more complex to measure than the other vital signs. This could potentially cause nurses to avoid measuring it, unlike a team with more competence in GCS measurement.

Documentation of pain assessment was poorer for team patients than standard care patients. We adjusted for deranged vital signs, which included patients with decreased consciousness, one factor that could influence this documentation. The better result for standard care patients could be due to the triage process, in which pain assessment is integrated.[33] It could also be that teams responding to alerts of critical patients focus on lifesaving interventions, at the expense of pain assessment. Another explanation could be that in patients who clearly are in pain, the pain is managed without first documenting pain assessment. This is supported by the finding that more team patients received analgesic within 20 min. We nevertheless argue that documentation of pain assessment should be an integrated part of any assessment of conscious patients, and a team should have the resources to do this alongside other interventions.

In a general patient population of critically ill as this, different diagnosis will require different treatment, of which only a few will be time-critical in the same way as for the abovementioned patient groups. There is a need to develop quality indicators specific for critically ill general medical patients in the future.

Resource use

The odds for receiving critical care in the ED were more than 9 for the team patients compared to standard care patients, despite adjusting for several factors including deranged vital signs. The presence of team members with critical care competencies could be a reason for this, as they most likely are better at identifying patients who need these interventions and have the skills to perform them. It could also be that when a team alert is used, the anticipation of team members is that the patient truly is critically ill. This could cause initiation of critical care interventions like arterial line insertion, also when this might not be necessary. It is also possible that an unknown factor, such as severity of the illness, not covered by adjusting factors,, was present in the team patients.

The shorter ED LOS when patients were managed by team is in line with other studies.[13, 17] Prolonged ED LOS are thought to impact on quality of initial care, and can thus cause prolonged ventilator time in the ICU and even increase mortality.[12] It seems logical that a multidisciplinary team with more people and better critical care competencies manages patients quicker and with higher quality than standard care management. We also believe that in our setting the reduced ED LOS is caused by the team leader being a medical registrar with easy access to medical ICU beds.

Patient outcome

The odds for ICU admission were higher for patients managed by team compared to those receiving standard care, despite adjusting for factors that could impact on ICU admission, such as deranged vital signs and receiving critical care in the ED. This could be due to factors already discussed; the competencies of the team to identify patients in need of ICU admission could be better than that of those giving standard care. It could also be due to the team management itself; an anticipation that the patient is critically ill due to the team alert, as well as easy access to ICU beds and willingness to increase level of care for team patients.

Management by team was also associated with increased odds of mortality. The mortality variable was a combination of mortality during hospital stay and 30 day mortality, and thus an outcome quite far away in time from initial management in the ED. The use of outcomes far away in time from the ED stay when investigating ED management have been criticized, as factors after the ED stay may influence outcome.[34] It could also be that the team patients were sicker than the standard care patients, and that a factor not controlled for by adjusting for deranged vital signs was present. An unknown factor such as poor prognosis of condition, on which we had no data, could influence mortality.

The other factors far away in time from the ED stay; ICU LOS and hospital LOS, were not affected by team management in the multivariate analyses, despite median LOS being shorter in univariate analysis. We believe the reasons could be similar to those discussed for mortality.

Limitations

This study collected data from two quality registers with data from medical records. The registers contained data mainly about ED management, and few data from the post ED period. This limited the analyses of long-term outcomes such as mortality, ICU LOS and hospital LOS. Influencing factors such as complications, adverse events or decisions regarding limitation of treatment after the ED stay could not be adjusted for. This limitation in data does however mimic real life in ED management. It should be emphasized that ED management should be the best considering available data at the moment. As such, data on ED processes could be more interesting than long term outcomes on which several later factors may be influential. We have also previously suggested that later outcomes may be less relevant than outcomes close to the ED stay, and have recommended use of 24 or 48 hour mortality,[35] if available.

The use of register data also limited the amount of quality indicators that could be investigated. One interesting indicator would have been patient satisfaction; this was not present in the registers. This could be difficult to investigate also with other methods, due to the critical illness of the patients. Using data from registers reduced selection bias and contributed to a high inclusion rate, as all triage 1 and every 5th triage 2 patients were included in the registers.

The observational nature of the study makes it difficult to draw conclusions about cause and effect of the two types of management under investigation. The use of multivariate analysis made it possible to investigate associations, which enhance the knowledgebase for the management of this patient group, and could be a starting point for future research. The study was also from a single ED, and may not be representative for other EDs.

We included patients with one or two missing NEWS2 part scores. Presence of the missing scores could have resulted in a NEWS2 higher than 10 points, the upper limit for inclusion. More triage 2 than triage 1 patients had missing NEWS2 part scores, and thus potentially higher NEWS2, so we do not believe inclusion of patients with missing part scores have impacted on the results

Considerations for future research and practice

We recommend prospective interventional studies in the future, preferably multisite and international, to gain more knowledge about the best ED management of this, in our opinion, often downgraded patient group.

In addition, cost-analysis studies would give knowledge of other aspects of resource use than in the present study, and could inform ED and hospital managers in how to manage this patient group in a way that is high in quality without overusing resources.

Future observational research should include potential confounding variables from the post-ED period if investigating late outcomes. It should also include data concerning the prognosis of the patients'conditions, also a potential confounding factor.

Our findings support findings from previous studies of similar or comparable patient groups, suggesting that emergency response team improves quality of care and processes in the ED for critically ill medical patients. We therefore recommend implementation of such teams in more EDs, preferably in conjunction with studies evaluating effect.

CONCLUSION

We found that management by a multidisciplinary emergency response team had a positive association with several outcomes for quality of care; implying that quality is improved when critically ill medical patients are managed by a team compared to receiving standard care. Outcomes for resource use were ambiguous; team management was associated with shorter ED LOS, but more critical care. For patient outcomes after the initial ED treatment the results were divergent; team management had no association with ICU LOS and hospital LOS, but was associated with increased mortality. It was also associated with ICU admission, an outcome closer in time.

As a starting point this observational study found promising results on managing critically ill medical patients with an emergency team rather than standard care. Further studies, preferably of prospective and interventional character, should be performed to investigate the most optimal and cost-effective management of this patient group in the future.

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Credit author statement

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Conflict of interest

None

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Data sharing statement

The dataset analyzed during the current study are not publicly available due to restrictions from the Data Protection Officer at OUH.

Competing interests

The authors declare that they have no competing interests.

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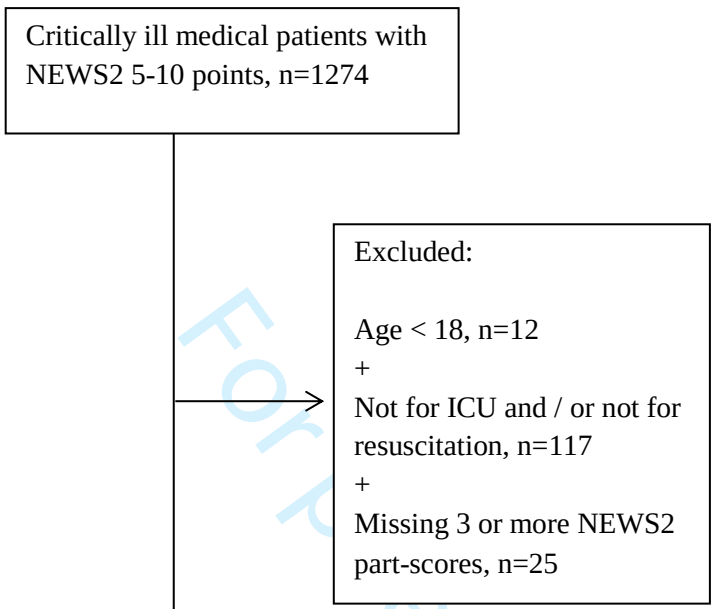
LEGENDS TO FIGURES

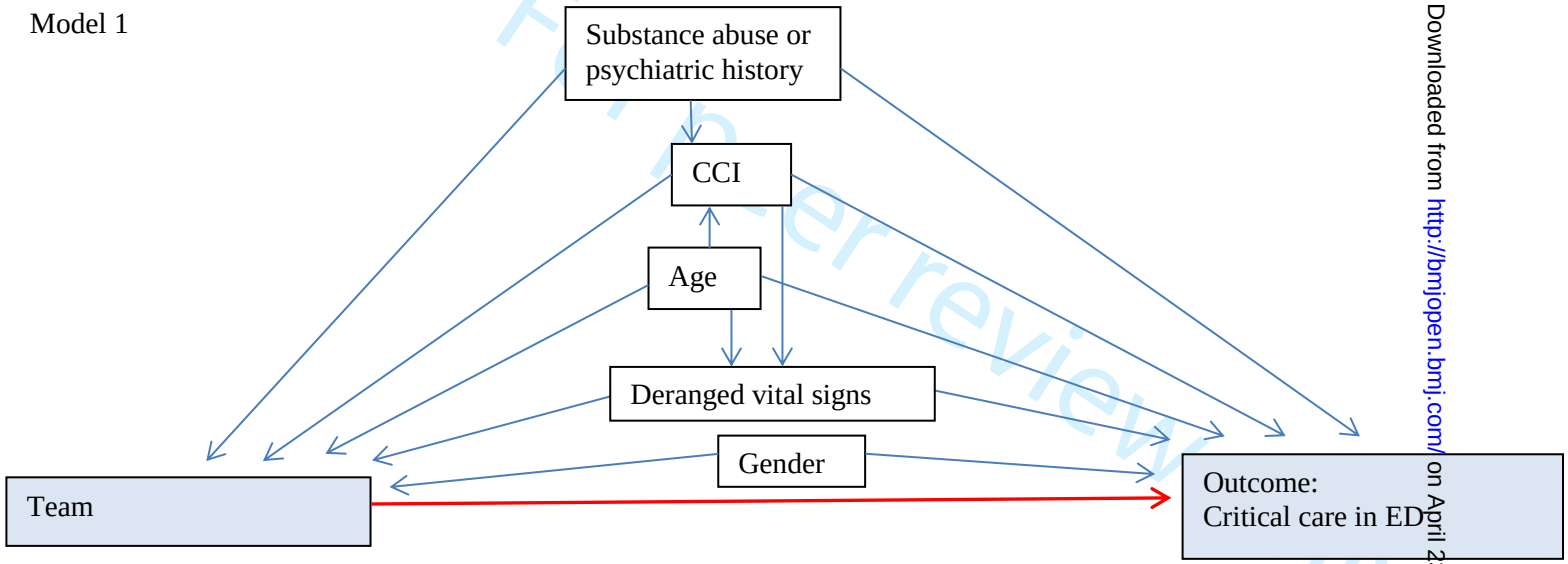
Figure 1: Flowchart of included and excluded patients

Figure 1

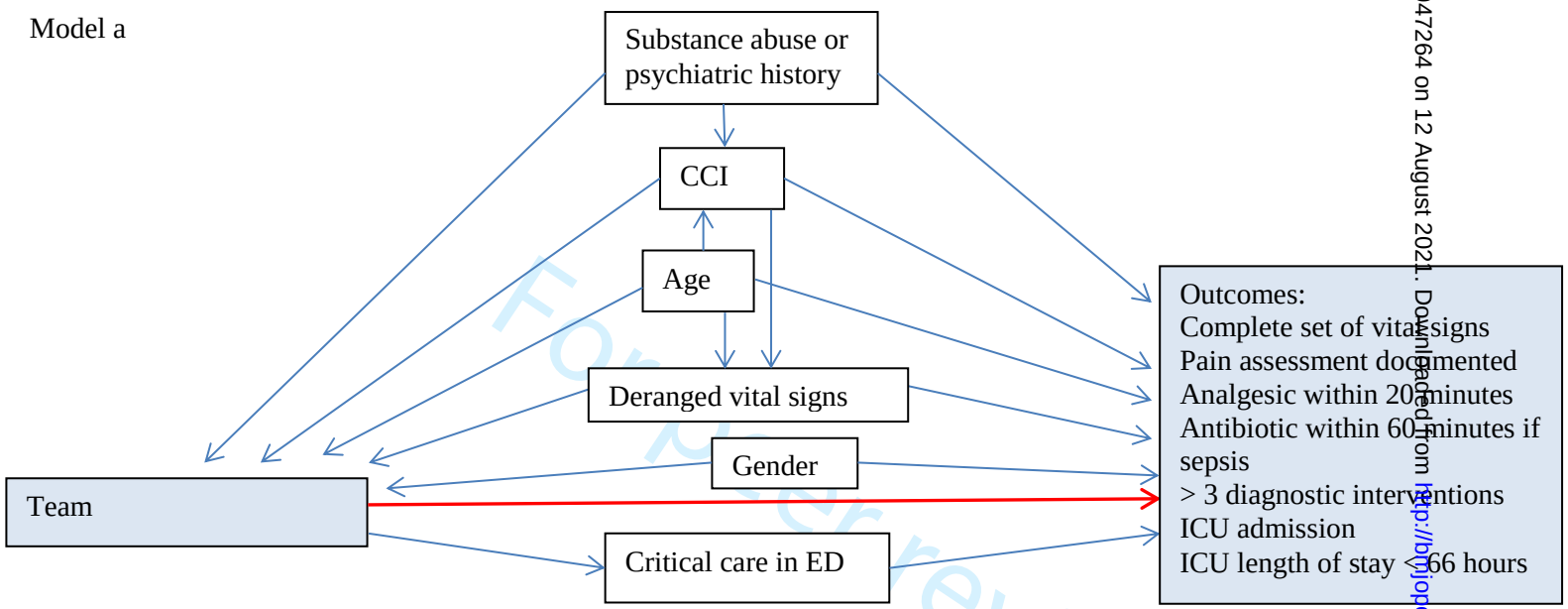


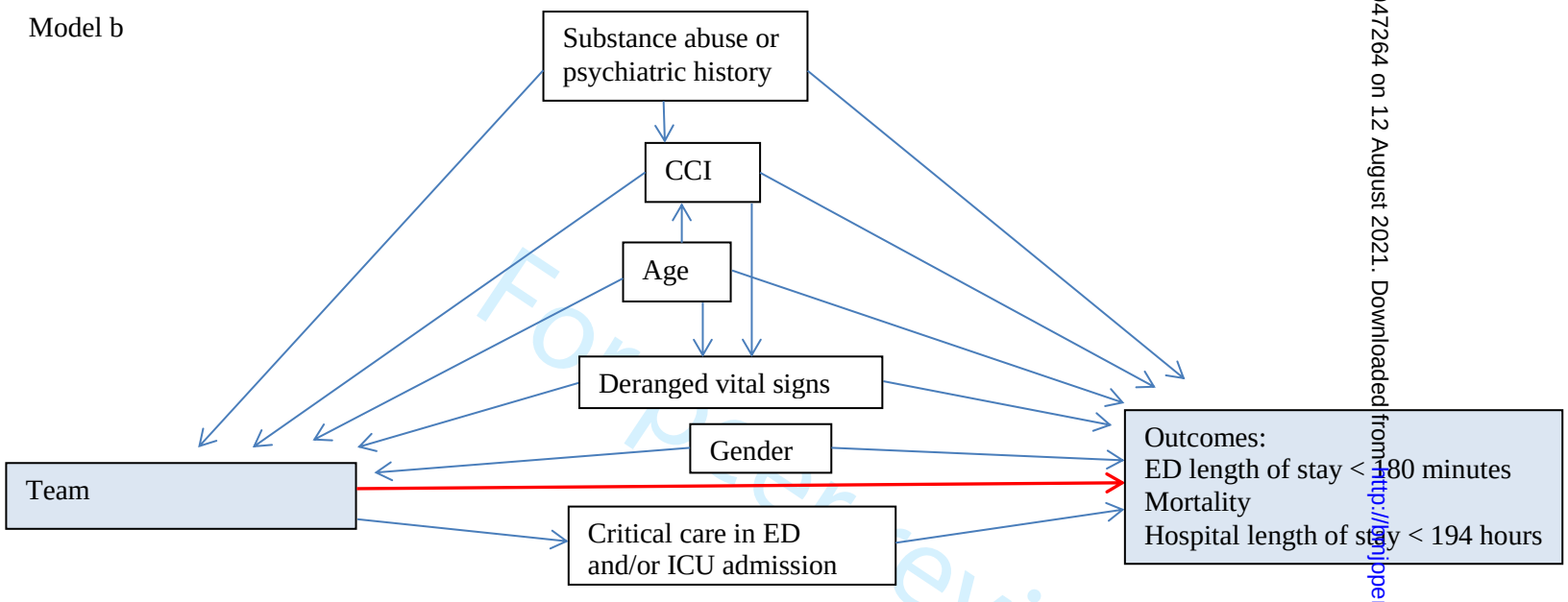
Multivariate logistic regression models

Model 1



Model a





Legend: Red arrow: timeline from management at arrival to outcome (blue boxes). White boxes: Factors potentially influencing management or outcome. Blue arrows: direction of influence.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5, fig1
		(b) Give reasons for non-participation at each stage	5, fig 1
		(c) Consider use of a flow diagram	fig1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10, table 2+3
		(b) Indicate number of participants with missing data for each variable of interest	7-10, table 2+3
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9-11, table 3
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-12, table 4
		(*b*) Report category boundaries when continuous variables were categorized	6-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Quality of care, resource use and patient outcome by use of emergency response team compared to standard care for critically ill medical patients in the Emergency Department: A retrospective single-center cohort study from Norway

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TITLE PAGE

Title

Quality of care, resource use and patient outcome by use of emergency response team compared to standard care for critically ill medical patients in the Emergency Department: A retrospective single-center cohort study from Norway.

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ABSTRACT

Objectives: To investigate quality of care, resource use and patient outcome in management by an emergency response team versus standard care for critically ill medical patients in the Emergency Department (ED). The emergency response team was multidisciplinary and had eight members, with a registrar in internal medicine as team leader.

Design: Register-based retrospective cohort study

Setting: Tertiary hospital in Norway

Participants: 1120 patients with National Early Warning Score 2 (NEWS2) 5-10 points from 2015 and 2016. Patients missing ≥ 3 NEWS2 part-scores, < 18 years and with orders 'Not for ICU' or 'Not for resuscitation' were excluded.

Outcome measures: Quality of care: pain assessment documented, analgesic given within 20 minutes, complete set of vital signs documented, and antibiotics within 60 minutes if sepsis. Resource use: > 3 diagnostic interventions, critical care in ED, and ED length of stay (LOS) < 180 minutes. Patient outcome: Intensive care unit (ICU) admission, ICU LOS < 66 hours, hospital LOS < 194 hours, and mortality.

Results: Median age was 66 years, 53.5% were male, 44.3% were admitted to ICU and mortality rate was 10.6%. Altogether 691 patients received team management and 429 standard care. Team management had a positive association with 'complete set of vital signs' (OR 1.720, CI 1.254-2.360), 'analgesic within 20 minutes' (OR 3.268, CI 1.375-7.767) and 'antibiotic within 60 minutes if sepsis' (OR 7.880, CI 3.322-18.691), but a negative association with 'documentation of pain assessment' (OR0.068, CI 0.037-0.128). Team management was also associated with 'critical care in ED' (OR9.900, OR 7.127-13.751), 'ED length of stay (LOS) < 180 minutes' (OR2.944, CI 2.070-4.187), 'ICU admittance' (OR2.763, OR 1.962-3.891) and 'mortality' (OR1.882, CI 1.142-3.102).

Conclusions: Team management showed positive results for quality of care and resource use. The results for later outcomes such as mortality, ICU LOS and hospital LOS were more ambiguous.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The use of register data made it possible to include a large group of patients
- Multivariate analysis allowed adjustment for several factors that could influence on the outcomes
- The observational nature of the study makes it difficult to draw conclusions about cause and effect of the two types of management under investigation
- The registers did not include data on all cofactors relevant for late outcomes
- The single-center design could limit representativeness

INTRODUCTION

The use of multidisciplinary emergency response teams has become more widespread over the last years, in a variety of settings and for different patient groups, also in the Emergency Department (ED). Trauma teams and cardiac arrest teams have existed for several decades.[1, 2] Teams for specific conditions such as myocardial infarction and stroke have become more common,[3, 4] as have the use of medical emergency teams or critical care outreach for deteriorating ward patients.[2, 5]

Management by emergency response teams have promising effects on time to treatment, mortality and morbidity in specific conditions such as trauma, stroke, sepsis and ST-elevation myocardial infarction.[6-10] The effect on more undifferentiated conditions such as in deteriorating ward patients is more unclear.[11] The use of team could divert resources away from other patients and be time-consuming and expensive,[11] and it is therefore important to correctly identify which patients benefit from it.

It is well known that critically ill patients in need of intensive care unit (ICU) admission could receive suboptimal care in the ED, and that prolonged ED length of stay (LOS) may cause sentinel events and even increase mortality.[12-14] Despite this, and the knowledge about the positive effect of emergency response teams for other patient groups, only a few studies have investigated the use of emergency response teams for critically ill general medical patients in the ED. These studies found that although many EDs do not use such teams, team management could ensure early diagnosis and treatment and a shorter ED LOS.[15-17]

In 2013 our hospital implemented an emergency response team for critically ill general medical patients in the ED, after several years with similar teams for trauma and cardiac arrest patients. In order to contribute to the knowledgebase about team management of these patients in the ED setting, we aimed to investigate the use of team versus standard care for this patient group. The objectives were to investigate how management by team was associated with ED quality of care, ED resource use and patient outcome, compared to standard care.

METHODS

Study setting

This retrospective single-center cohort study used register data from 2015 and 2016 from Oslo University Hospital (OUH) Ullevål, a tertiary hospital with all sub-specialties in internal medicine. The ED is considered large-volume with 28 000 patients in 2015 and an admittance rate of 90%. Half of the admitted patients were adult medical patients. In Norway self-referral is rare. Patients are usually referred to the ED by primary care physicians or ambulance personnel by telephone before arrival. No emergency medicine specialty existed at the time of the study, and patients were reviewed in the

ED by on-call specialists (in internal medicine, orthopedic, neurology etc) appropriate to their presenting complaint.

In addition to an emergency response team for critically ill medical patients, the ED also had teams for trauma patients, cardiac arrest patients, critically ill children, patients with ST-elevation myocardial infarction and for patients with stroke considered for thrombolysis, the latter from 2016.

All team patients were categorized as triage 1. All other patients were triaged according to Manchester Triage System. Triage was an ongoing process, and all patients could be assigned a different triage category later in the ED stay than at arrival if their condition changed. This included alerting the relevant emergency response team if criteria was present. No rapid response team existed in the hospital or in the ED.

Participants and management

Triage 1 and 2 patients referred to the medical specialties were considered to be potentially critically ill and eligible for inclusion. Triage 1 patients were mostly identified prior to arrival or at ED triage by using a single-parameter criteria system, hereafter called the OUH-criteria. They were managed in resuscitation rooms by a multidisciplinary team (table 1). The team was led by a registrar in internal medicine, and the patients were assessed and managed using an ABCDE-approach. Triage 2 patients were seen immediately by an ED nurse and within 10 minutes by a registrar in internal medicine, and thus received what is defined as standard care in this study. If needed, care was supplemented by additional ED nurses and/or physicians.

To reduce heterogeneity in acuity between the two groups, we only included patients with National Early Warning Score 2 (NEWS2) 5-10 points, excluding those missing 3 or more NEWS2 part-scores. A cut-off of ≥ 5 was chosen because of its increased risk of serious clinical outcome and recommendation as a threshold for urgent clinical review by a clinician or team.[18] A cut-off of ≤ 10 was chosen due to few triage 2 patients with higher scores and to avoid outliers that obviously were critically ill. We excluded patients under 18 years and those with the orders Not for resuscitation or Not for ICU given in the ED (figure 1).

Table 1. OUH-criteria and members of emergency response team

OUH-criteria	**Team members**
Threatened airway	Registrar in internal medicine (team leader)
Respiratory arrest	Registrar in anesthesiology
Respiration rate < 8 or > 40*	ED nurses (3)
Oxygen saturation < 85 % *	Nurse anesthetist
Systolic blood pressure < 90 mmHg*	Phlebotomist
Pulse < 35 or > 130*	Radiographer
GCS < 9*	If needed supplemented by: Registrar in cardiology Registrar in neurology
Persistent/continuous fitting	
Temperature < 32*	

Clinical concern by prehospital personnel, ED doctor or ED nurse	Registrar other subspecialty

OUH: Oslo University Hospital, * vital sign criteria, GCS: Glasgow Coma Scale, ED: Emergency Department

Data sources and sample size

Data on triage 1 patients were retrieved from a quality register containing data from medical records on all medical triage 1 patients from 2015 and 2016, except 44 patients not holding a Norwegian social security number (n=1294). Data on triage 2 patients were retrieved from a quality register containing similar data on every 5th admitted medical triage 2 patient from the same time period (n=1426). In the latter register every 5th arriving patient had been chosen in order to get a similar amount of patients as in the register for triage 1 patients, and to get a spread in time of day, week and year.

Sample size was a pragmatic choice and not calculated, as inclusion was limited to eligible patients from the registers. By applying the rule of ten,[19] the sample size was considered sufficient for the analyses chosen.

Outcomes and variables

Quality of care was investigated using four outcomes: pain assessment documented,[20] analgesic given within 20 minutes,[21] complete set of vital signs documented,[22] and antibiotics within 60 minutes if sepsis.[23] Vital signs included respiration rate, SpO2, pulse, blood pressure, temperature and Glasgow Coma Scale.[22] Sepsis was defined as infection being the main discharge diagnosis and ≥ 2 qSOFA or ≥ 2 SIRS criteria present at arrival, thus covering both current diagnostic criteria and those used in the study period.[24]

Resource use was investigated using three outcomes: > 3 diagnostic interventions, critical care in ED and ED length of stay (LOS) < 180 minutes. Diagnostic interventions was defined as electrocardiogram, arterial blood gas, blood culture, other microbiological investigation, lumbar puncture, chest x-ray, other x-ray, computed tomography (CT) of head, other CT, cardiac ultrasound or other ultrasound. Critical care in ED was defined as one or more of the following interventions or medications: intubation, other airway interventions, non-invasive ventilation, arterial line, central venous line, pacing, cardioversion, cardiopulmonary resuscitation, pleural catheter or administration of blood products, sedatives, anesthetic agents, antiarrhythmics or vasopressors.[25]

Four outcomes were used to investigate patient outcome: ICU admission, ICU LOS < 66 hours, hospital LOS < 194 hours, and mortality. ICU admission was defined as admission to any ICU in the hospital directly from the ED. Mortality was defined as mortality at 30 days or hospital mortality later than 30 days.

The cut-offs for ED, ICU and hospital LOS was made using the 75 percentiles. All outcome variables were dichotomous.

In multivariate analysis Charlson Comorbidity Index (CCI)[26] and history of substance abuse and/or psychiatric illness were used as comorbidity variables, the first was categorized as 0p, 1-2p, 3-4p and >4p,[27] the latter was dichotomous. The variable 'deranged vital signs' was defined as Glasgow Coma Scale (GCS) <15 or NEWS 7-10 or OUH-criteria at arrival, and was dichotomous.

Other variables included presenting complaint, which was grouped into categories based on frequency, and main discharge diagnoses which was grouped accordingly.

Statistical analysis

Analyses were performed using IBM SPSS® version 25.0 for Windows (Armonk, NY, USA). Continuous variables are presented as median with interquartile range (IQR) and categorical variables as number and percentage. Separate n's are reported for variables with missing items from the registers. Group-comparison used Mann-Whitney rank sum test for continuous and Chi-square test or exact test for categorical variables, and was two-sided.

Multivariate logistic regression was used to investigate association with the outcomes, and clinical rationale was used to build the models (supplement 1). For all outcomes we adjusted for gender, age, CCI, history of substance abuse and/or psychiatric history and deranged vital signs. For complete set of vital signs, pain assessment documented, analgesic within 20 minutes, antibiotics within 60 minutes if sepsis, > 3 diagnostic interventions, ICU admission and ICU LOS < 66 hours we also adjusted for critical care in ED. For the other outcomes, except critical care in ED, we adjusted for critical care in ED and/or ICU admission. For all outcomes we did sensitivity analyses, where also presenting problem was adjusted for, as this variable was considered to also be a potential confounder. Unadjusted and adjusted odds ratio (OR) with confidence intervals (CI), as well as p-values, are presented. The goodness of fit was assessed using Hosmer-Lemeshow test.

A p-value < 0.05 was regarded as statistically significant in all analysis.

Ethics

All data were register data extracted from medical records, and treatment was not affected. Informed consent was therefore waived, and the study was approved by the Data Protection officer at OUH (2016/10319).

Patient and public involvement

Patients or the public were not involved in any phase of this study.

RESULTS

Patient characteristics

A total of 1120 patients, of which 691 (61.7%) were managed by team, met the inclusion criteria. Median age was 66 years, 599 (53.5%) were male, and respiratory (n=245, 22.4%) and infection (n=211, 19.3%) problems were the most common presenting complaints (table 2). Patients managed by the team were younger (p<0.001), more were male (p<0.05), and they had lower CCI but more history of substance abuse and/or psychiatric illness than those who received standard care (both p<0.001). More team patients also had OUH vital sign criteria present,NEWS2 7-10 points, decreased GCS and deranged vital signs (all p<0.001). Presenting complaint and discharge diagnoses differed between the two groups (both p<0.001), with acute poisoning being dominant for team patients and infection dominant for standard care patients.

Table 2. Patient characteristics

	Whole cohort (n=1120)	Team (n=691)	Standard (n=429)
Age, median (IQR)	66 (34)	60 (38)**	73 (23)
Male gender	599 (53.5%)	391 (56.6%)*	208 (48.5%)
Charlson Comorbidity Index (n=664+424)		**	
0p	413 (38.7%)	292 (45.3%)	121 (28.5%)
1-2p	469 (43.8%)	249 (38.7%)	219 (51.7%)
3-4p	131 (12.3%)	73 (11.3%)	58 (13.7%)
>4p	56 (5.2%)	30 (4.7%)	26 (6.1%)
History of substance abuse and/or psychiatric illness	296 (26.4%)	238 (34.4%)**	58 (13.5%)
Presenting complaint (n=689+407)		**	
Cardiac/circulatory	163 (14.9%)	79 (11.5%)	84 (20.6%)**
Acute poisoning	193 (17.6%)	174 (25.3%)	19 (4.7%)**
Respiratory	245 (22.4%)	147 (21.3%)	98 (24.1%)
Consciousness/neurologic	201 (18.3%)	183 (26.6%)	18 (4.4%)**
Abdominal	35 (3.2%)	29 (4.2%)	6 (1.5%)*
Infection	211 (19.3%)	60 (8.7%)	151 (37.1%)**
Other	48 (4.4%)	17 (2.5%)	31 (7.6%)**
OUH vital sign criteria present at arrival	435 (38.8%)	327 (47.3%)**	108 (25.2%)
NEWS2-score		**	
5	216 (19.3%)	102 (14.8%)	114 (26.6%)
6	248 (22.1%)	144 (20.8%)	104 (24.2%)
7	223 (19.9%)	128 (18.5%)	95 (22.1%)
8	184 (16.4%)	129 (18.7%)	55 (12.8%)
9	144 (12.9%)	105 (15.2%)	39 (9.1%)
10	105 (9.4%)	83 (12.0%)	22 (5.1%)
NEWS2 7-10 points	656 (58.6%)	445 (64.4%)**	211 (49.2%)
GCS (n=565+280)		**	
13-15	554 (65.6%)	295 (52.2%)	259 (92.5%)
9-12	84 (9.9%)	71 (12.6%)	13 (4.6%)
<9	207 (24.5%)	199 (35.2%)	8 (2.9%)
Deranged vital signs (NEWS 7-10 or GCS<15 or OUH criteria)	873 (77.9%)	604 (87.4%)**	269 (62.7%)

Primary discharge diagnosis (n=690+428)		**	
Cardiac/circulatory	229 (20.5%)	131 (19.0%)	98 (22.9%)
Poisoning	214 (19.1%)	192 (27.8%)	22 (5.1%)
Respiratory	117 (10.5%)	70 (10.1%)	47 (11.0%)
Neurologic	57 (5.1%)	56 (8.1%)	1 (0.2%)
Abdominal	85 (7.6%)	42 (6.1%)	43 (10.0%)
Infection	309 (27.6%)	125 (18.1%)	184 (43.0%)
Others	107 (9.6%)	74 (10.7%)	33 (7.7%)

IQR: interquartile range, OUH: Oslo University Hospital, NEWS2: National early warning score 2, GCS: Glasgow coma scale, *p<0.05, **p<0.001

Quality of care

Pain assessment was documented for 132 (11.8%) patients, and for 720 (64.3%) a complete set of vital signs were documented (table 3). Of the 291 (26.0%) patients receiving analgesic, 69 (24.3%) received it within 20 minutes. Antibiotic treatment was started within 60 minutes to a total of 86 (49.7%) sepsis patients . In univariate analyses significantly fewer team than standard care patients had pain assessment documented, but more had a complete set of vital signs documented at arrival (both p<0.001) (table 3). More also received analgesic within 20 minutes and antibiotic within 60 minutes if sepsis, and the median time to analgesic and antibiotic were shorter (all p<0.001).

Table 3. Quality of care, resource use and patient outcome – univariate analysis

	Whole cohort (n=1120)	Team (n=691)	Standard (n=429)
Quality of care			
Pain assessment documented	132 (11.8%)	15 (2.2%)**	117 (27.3%)
Complete set of vital signs at arrival	720 (64.3%)	474 (68.6%)**	246 (57.3%)
Analgesic given	291 (26.0%)	188 (27.2%)	103 (24.0%)
Min to analgesic, median (IQR) (n=184+100)	43 (53.5)	32 (66)**	63 (66)
Analgesic within 20 min (n=184+100)	69 (24.3%)	57 (31.0%)**	12 (12.0%)
Sepsis (Infection + ≥ 2 qSOFA or ≥ 2 SIRS)	268 (23.9%)	113 (16.4%)**	155 (36.1%)
Antibiotic given (n=113+155)	179 (66.8%)	75 (66.4%)	104 (67.1%)
Min to antibiotic, median (IQR) (n=74+99)	60 (81)	30.5 (31.8)**	94 (75)
Antibiotic within 60 min (n=74+99)	86 (49.7%)	59 (79.7%)**	27 (27.3%)
Resource use			
Diagnostic interventions		**	
0	8 (0.7%)	7 (1.0%)	1 (0.2%)
1	78 (7.0%)	47 (6.8%)	31 (7.2%)
2	161 (14.4%)	115 (16.6%)	46 (10.7%)
3	274 (24.5%)	197 (28.5%)	77 (17.9%)
4	276 (24.6%)	167 (24.2%)	109 (25.4%)
5	253 (22.6%)	120 (17.4%)	133 (31.0%)
>5	70 (6.3%)	38 (5.5%)	32 (7.5%)
Diagnostic interventions > 3	599 (53.5%)	325 (47.0%)**	247 (63.9%)

Critical care in ED, any	525 (46.9%)	461 (66.7%)**	64 (14.9%)
Interventions	411 (36.7%)	390 (56.4%)**	21 (4.9%)
Medications	294 (26.3%)	244 (35.3%)**	50 (11.7%)
Critical care in ED and/or ICU admittance	663 (59.2%)	551 (79.7%)**	112 (26.1%)
ED LOS			
median min (IQR)	116 (109)	91 (78)**	161 (111)
< 180 min	840 (75.0%)	586 (84.8%)**	254 (59.2%)
Patient Outcome			
ICU admittance	496 (44.3%)	416 (60.2%)**	80 (18.6%)
ICU LOS			
median hours (IQR) (n=416+80)	27.5 (52)	25.5 (50)*	42.5 (68)
< 66 hours (n=416+80)	369 (74.4%)	316 (76.0%)	53 (66.3%)
Hospital LOS			
median hours (IQR)	96 (169)	67 (174)**	125 (143)
< 194 hours	838 (74.8%)	525 (76.0%)	313 (73.0%)
Mortality at 30 days / hospital discharge	119 (10.6%)	79 (11.4%)	40 (9.3%)

min: minutes, IQR: interquartile range, ICU: intensive care unit, ED: emergency department, LOS: length of stay, *p<0.05, **p<0.001

In multivariate analyses team management continued to be associated with having a complete set of vital signs (OR 1.720, CI 1.254-2.360), less documentation of pain assessment (OR 0.068, CI 0.037-0.128), to receive analgesic within 20 minutes (OR 3.268, CI 1.375-7.767) and antibiotic within 60 minutes if sepsis (OR 7.880, CI 3.322-18.691) (table 4). Sensitivity analyses adjusting also for presenting complaint did not alter the results (supplement 2).

Table 4. Multivariate analyses of team management versus standard care (n=1068 unless otherwise stated)

Outcomes	**Crude OR (CI)**	**Adjusted OR (CI)**[1]
Quality of care		
Complete set of vital signs[a]	1.625 (1.266-2.086)**	1.720 (1.254-2.360)*
Pain assessment documented[a]	0.059 (0.034-0.103)**	0.068 (0.037-0.128)**
Analgesic within 20 minutes[a] (n=272)	3.291 (1.669-6.492)*	3.268 (1.375-7.767)*
Antibiotic within 60 minutes if sepsis[a] (n=170)	10.489 (5.111-21.525)**	7.880 (3.322-18.691)**
Resource use		
Diagnostic interventions > 3[a]	0.502 (0.392-0.643)**	0.749 (0.545-1.030)
Critical care in ED	11.431 (8.391-15.572)**	9.900 (7.127-13.751)**
ED LOS < 180 minutes[b]	3.845 (2.897-5.104)**	2.944 (2.070-4.187)**
Patient outcome		
ICU admittance[a]	6.599 (4.954-8.791)**	2.763 (1.962-3.891)**
ICU LOS < 66 hours[a] (n=464)	1.610 (0.962-2.695)	1.374 (0.764-2.472)
Hospital LOS < 194 hours[b]	1.172 (0.890-1.544)	1.194 (0.837-1.703)
Mortality[b]	1.255 (0.841-1.875)	1.882 (1.142-3.102)*

OR: Odds ratio, CI: confidence interval, ED: emergency department, LOS: length of stay, ICU: intensive care unit, *p<0.05, **p<0.001, [1] all adjusted for age, gender, Charlson comorbidity score,

substance abuse or psychiatric history and deranged vital signs, [a] adjusted for critical care in ED, [b] adjusted for critical care in ED and/or ICU admission

Resource use

Critical care was given to 525 (46.9%) patients in the ED and 599 (53.5%) had > 3 diagnostic interventions (table 3). Significantly more team than standard care patients received critical care in ED in univariate analyses, but fewer had > 3 diagnostic interventions (both p<0.001) (table 3). They had shorter median ED LOS than standard care patients, and more had ED LOS < 180 minutes (both p<0.001).

In multivariate analyses management by team continued to be associated with receiving critical care in ED (OR 9.900, CI 7.127-13.751) and a ED LOS < 180 minutes (OR 2.944, CI 2.070-4.187) (table 4). Sensitivity analyses adjusting also for presenting complaint did not alter the results (supplement 2).

Patient outcome

A total of 496 (44.3%) patients were admitted to ICU and 119 (10.6%) were dead at 30 days or hospital discharge. Significantly more team than standard care patients were admitted to ICU in univariate analyses (p<0.001) (table 3). They had shorter median ICU LOS (p<0.05) and hospital LOS (p<0.001) than standard care patients. There were no differences in ICU LOS < 66 hours, hospital LOS < 194 hours or mortality.

Management by team continued to be associated with being admitted to ICU (OR 2.763, CI 1.962-3.891) in multivariate analyses. It was also associated with mortality (OR1.882, CI 1.142-3.102) (table 4). No association was found with ICU LOS < 67 hours or hospital LOS < 194 hours. Sensitivity analyses adjusting also for presenting complaint did not alter the results (supplement 2).

DISCUSSION

For quality of care, management by team was associated with complete set of vital signs, administration of analgesic within 20 minutes and antibiotics within 60 minutes if sepsis. It was negatively associated with documentation of pain assessment. For resource use, management by team was associated with receiving critical care in ED and an ED LOS < 180 minutes. For patient outcome, association was found with ICU admittance and mortality. No association was found with ICU LOS < 66 hours or hospital LOS < 194 hours.

Quality of care

The investigation of quality of care in EDs often focuses on process indicators. Suggested indicators include time intervals such as length of stay, time to ED provider, time to analgesic, time to investigations and time to decisions and treatment.[20, 28, 29] Also percentage of patients with documented pain assessment is suggested,[20] as is having a full set of vital signs documented.[22]

We found few studies comparing effect of management by team on these processes for critically ill medical patients. One recent practice improvement study found that introduction of a team response to critically ill medical patients reduced the time of several ED processes, namely time to provider, laboratory, diagnostic imaging and admission.[17] We found that administration of analgesic within 20 minutes and antibiotic within 60 minutes if sepsis had better outcome by use of team compared to standard care. For sepsis patients a recent review found that management by a team improved sepsis resuscitation bundle, in which administration of antibiotics with 60 minutes is a major component.[10] This is consistent with our findings. Management by team is found to have a positive effect on door-to-needle time in patients with stroke and myocardial infarction,[7, 8] further supporting that team management is beneficial in reducing time-critical treatment.

Team management also had a positive association with documentation of a complete set of vital signs, which other studies have found to be incomplete in many ED patients.[30-32] Less documentation of vital signs at arrival in the standard care group is surprising, as local guidelines mandates vital signs to be documented at triage and throughout the ED stay. An Australian study found that the vital sign most commonly missing in ED documentation was GCS, [30] which in our study is missing more frequently for standard care than team patients. A reason for this could be that nurses tend to omit documentation of GCS when the patient is awake and alert, while it is considered more important to document if decreased. GCS is also more complex to measure than the other vital signs. This could potentially cause nurses to avoid measuring it, unlike a team with more competence in GCS measurement.

Documentation of pain assessment was poorer for team patients than standard care patients. We adjusted for deranged vital signs, which included patients with decreased consciousness, one factor that could influence this documentation. The better result for standard care patients could be due to the triage process, in which pain assessment is integrated.[33] It could also be that teams responding to alerts of critical patients focus on lifesaving interventions, at the expense of pain assessment. Another explanation could be that in patients who clearly are in pain, the pain is managed without first documenting pain assessment. This is supported by the finding that more team patients received analgesic within 20 min. We nevertheless argue that documentation of pain assessment should be an integrated part of any assessment of conscious patients, and a team should have the resources to do this alongside other interventions.

In a general patient population of critically ill as this, different diagnosis will require different treatment, of which only a few will be time-critical in the same way as for the abovementioned patient groups. There is a need to develop quality indicators specific for critically ill general medical patients in the future.

Resource use

The odds for receiving critical care in the ED were more than 9 for the team patients compared to standard care patients, despite adjusting for several factors including deranged vital signs. The presence of team members with critical care competencies could be a reason for this, as they most likely are better at identifying patients who need these interventions and have the skills to perform them. It could also be that when a team alert is used, the anticipation of team members is that the patient truly is critically ill. This could cause initiation of critical care interventions like arterial line insertion, also when this might not be necessary. It is also possible that an unknown factor, such as severity of the illness, not covered by adjusting factors,, was present in the team patients.

The shorter ED LOS when patients were managed by team is in line with other studies.[13, 17] Prolonged ED LOS are thought to impact on quality of initial care, and can thus cause prolonged ventilator time in the ICU and even increase mortality.[12] It seems logical that a multidisciplinary team with more people and better critical care competencies manages patients quicker and with higher quality than standard care management. We also believe that in our setting the reduced ED LOS is caused by the team leader being a medical registrar with easy access to medical ICU beds.

Patient outcome

The odds for ICU admission were higher for patients managed by team compared to those receiving standard care, despite adjusting for factors that could impact on ICU admission, such as deranged vital signs and receiving critical care in the ED. This could be due to factors already discussed; the competencies of the team to identify patients in need of ICU admission could be better than that of those giving standard care. It could also be due to the team management itself; an anticipation that the patient is critically ill due to the team alert, as well as easy access to ICU beds and willingness to increase level of care for team patients.

Management by team was also associated with increased odds of mortality. The mortality variable was a combination of mortality during hospital stay and 30 day mortality, and thus an outcome quite far away in time from initial management in the ED. The use of outcomes far away in time from the ED stay when investigating ED management have been criticized, as factors after the ED stay may influence outcome.[34] It could also be that the team patients were sicker than the standard care patients, and that a factor not controlled for by adjusting for deranged vital signs was present. An unknown factor such as poor prognosis of condition, on which we had no data, could influence mortality.

The other factors far away in time from the ED stay; ICU LOS and hospital LOS, were not affected by team management in the multivariate analyses, despite median LOS being shorter in univariate analysis. We believe the reasons could be similar to those discussed for mortality.

Limitations

This study collected data from two quality registers with data from medical records. The registers contained data mainly about ED management, and few data from the post ED period. This limited the analyses of long-term outcomes such as mortality, ICU LOS and hospital LOS. Influencing factors such

as complications, adverse events or decisions regarding limitation of treatment after the ED stay could not be adjusted for. This limitation in data does however mimic real life in ED management. It should be emphasized that ED management should be the best considering available data at the moment. As such, data on ED processes could be more interesting than long term outcomes on which several later factors may be influential. We have also previously suggested that later outcomes may be less relevant than outcomes close to the ED stay, and have recommended use of 24 or 48 hour mortality,[35] if available.

The use of register data also limited the amount of quality indicators that could be investigated. One interesting indicator would have been patient satisfaction; this was not present in the registers. This could be difficult to investigate also with other methods, due to the critical illness of the patients. Using data from registers reduced selection bias and contributed to a high inclusion rate, as all triage 1 and every 5th triage 2 patients were included in the registers.

The observational nature of the study makes it difficult to draw conclusions about cause and effect of the two types of management under investigation. The use of multivariate analysis made it possible to investigate associations, which enhance the knowledgebase for the management of this patient group, and could be a starting point for future research. The study was also from a single ED, and may not be representative for other EDs.

We included patients with one or two missing NEWS2 part scores. Presence of the missing scores could have resulted in a NEWS2 higher than 10 points, the upper limit for inclusion. More triage 2 than triage 1 patients had missing NEWS2 part scores, and thus potentially higher NEWS2, so we do not believe inclusion of patients with missing part scores have impacted on the results

Considerations for future research and practice

We recommend prospective interventional studies in the future, preferably multisite and international, to gain more knowledge about the best ED management of this, in our opinion, often downgraded patient group.

In addition, cost-analysis studies would give knowledge of other aspects of resource use than in the present study, and could inform ED and hospital managers in how to manage this patient group in a way that is high in quality without overusing resources.

Future observational research should include potential confounding variables from the post-ED period if investigating late outcomes. It should also include data concerning the prognosis of the patients'conditions, also a potential confounding factor.

Our findings support findings from previous studies of similar or comparable patient groups, suggesting that emergency response team improves quality of care and processes in the ED for critically ill medical patients. We therefore recommend implementation of such teams in more EDs, preferably in conjunction with studies evaluating effect.

CONCLUSION

We found that management by a multidisciplinary emergency response team had a positive association with several outcomes for quality of care; implying that quality is improved when critically ill medical patients are managed by a team compared to receiving standard care. Outcomes for resource use were ambiguous; team management was associated with shorter ED LOS, but more critical care. For patient outcomes after the initial ED treatment the results were divergent; team management had no association with ICU LOS and hospital LOS, but was associated with increased mortality. It was also associated with ICU admission, an outcome closer in time.

As a starting point this observational study found promising results on managing critically ill medical patients with an emergency team rather than standard care. Further studies, preferably of prospective and interventional character, should be performed to investigate the most optimal and cost-effective management of this patient group in the future.

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Credit author statement

Stine Engebretsen: Conceptualization, Methodology, Formal analysis, Writing – original draft

Dag Jacobsen: Conceptualization, Methodology, Writing – review and editing, Supervision

Stig Tore Bogstrand: Conceptualization, Methodology, Writing – review and editing, Supervision

Rune Rimstad: Conceptualization, Methodology, Writing – review and editing, Supervision, Project administration

Conflict of interest

None

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Data sharing statement

The dataset analyzed during the current study are not publicly available due to restrictions from the Data Protection Officer at OUH.

Competing interests

The authors declare that they have no competing interests.

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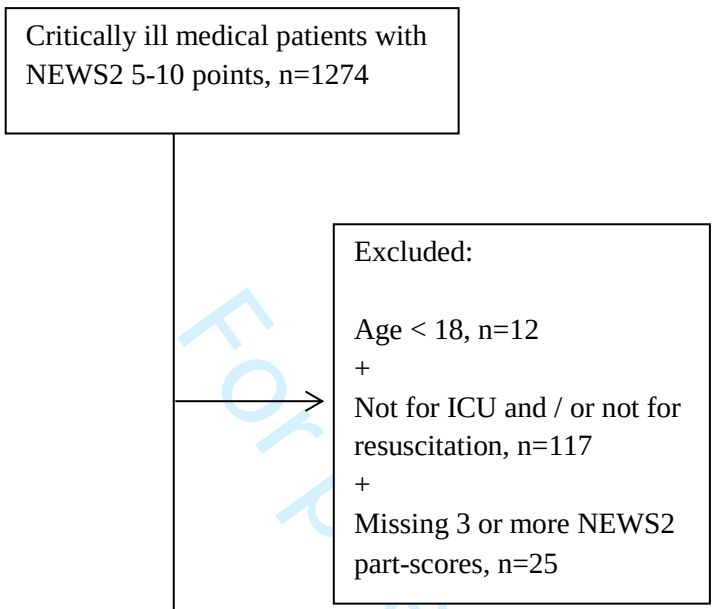
LEGENDS TO FIGURES

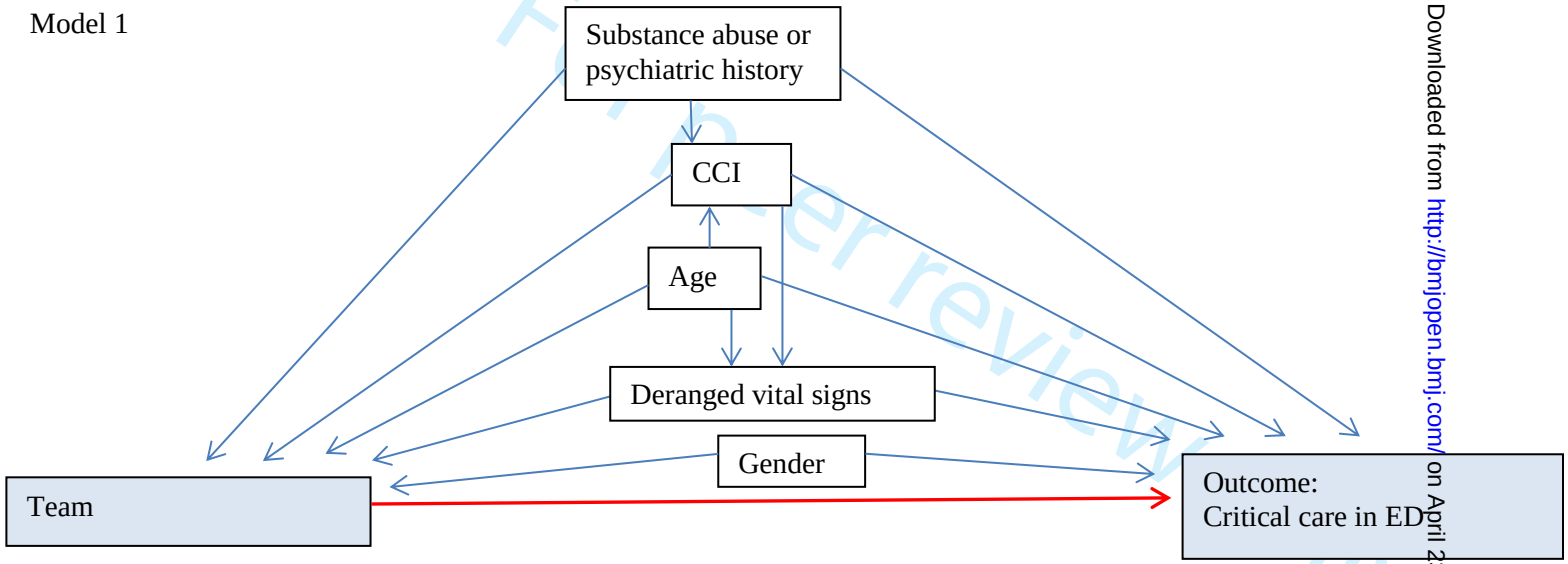
Figure 1: Flowchart of included and excluded patients

Figure 1

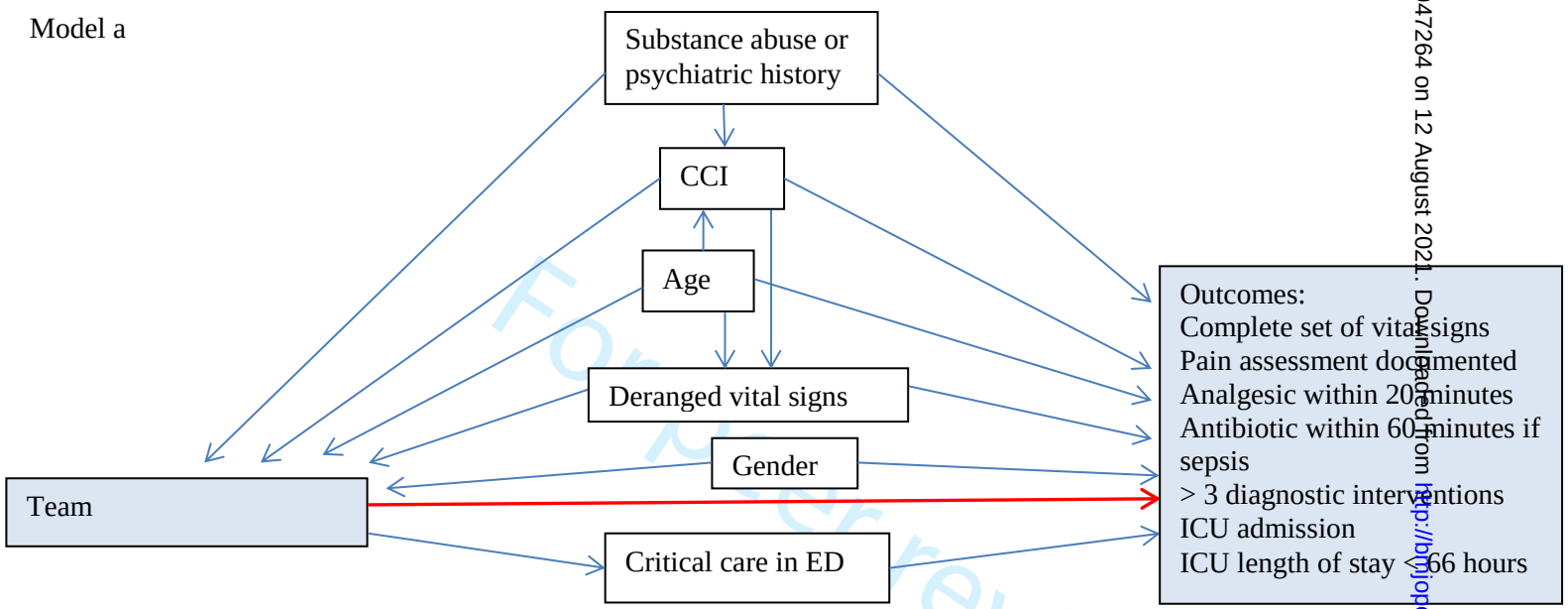


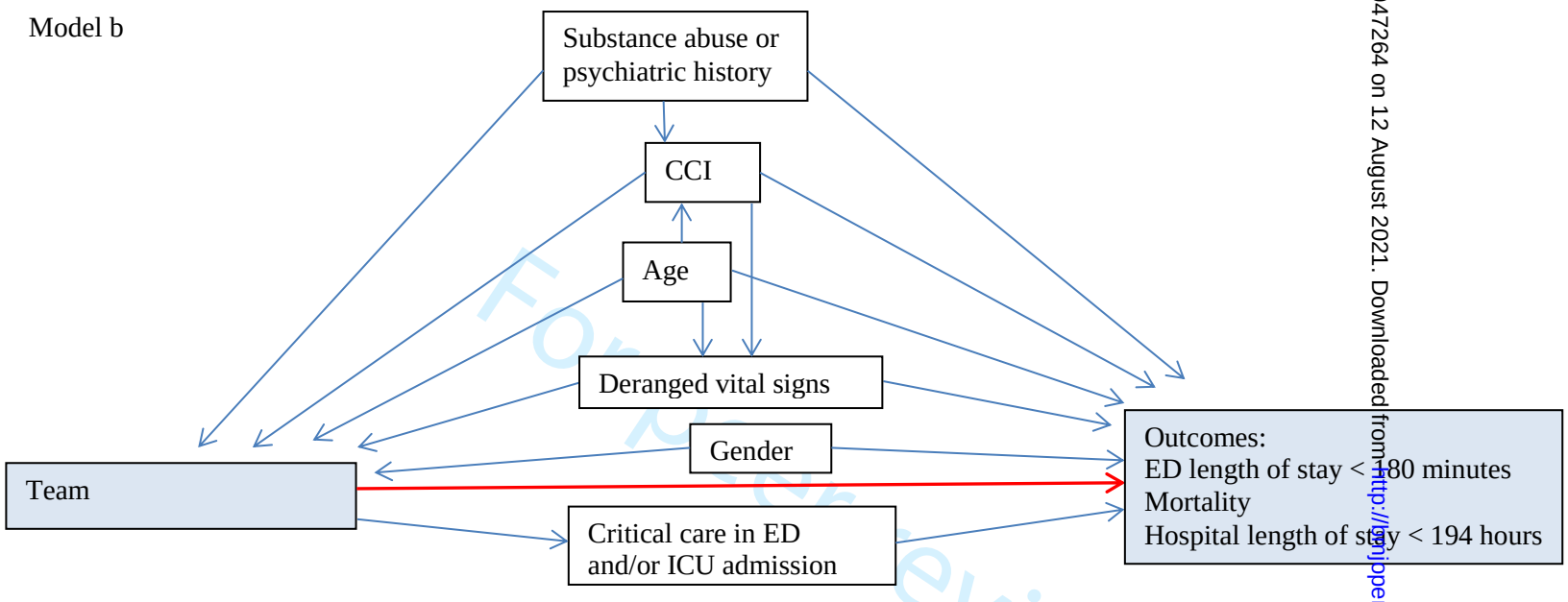
Multivariate logistic regression models

Model 1



Model a





Legend: Red arrow: timeline from management at arrival to outcome (blue boxes). White boxes: Factors potentially influencing management or outcome. Blue arrows: direction of influence.

Supplement 2. Sensitivity analysis, also adjusting all outcomes for presenting complaint

Outcomes	**Adjusted OR (CI)**[1]
Quality of care:	
Complete set of vital signs[a]	1.476 (1.048-2.079)*
Pain assessment documented[a]	0.071 (0.036-0.139)**
Analgesic within 20 minutes[a] (n=266)	3.260 (1.318-8.064)*
Antibiotics within 60 minutes if sepsis[a] (n=167)	11.951 (4.490-31.811)**
Resource use:	
Diagnostic interventions > 3[a]	0.804 (0.552-1.171)
Critical care in ED	10.138 (6.969-14.752)**
ED LOS < 180 minutes[b]	3.192 (2.146-4.749)**
Patient outcome:	
ICU admittance[a]	2.864 (1.962-4.181)**
ICU LOS < 66 hours[a] (n=457)	0.736 (0.377-1.439)
Hospital LOS < 194 hours[b]	0.991 (0.672-1.462)
Mortality[b]	1.859 (1.072-3.221)*

OR: Odds ratio, CI: confidence interval, ED: emergency department, LOS: length of stay, ICU: intensive care unit, *p<0.05, **p<0.001

[1] all adjusted for age, gender, Charlson comorbidity score, substance abuse or psychiatric history, deranged vital signs and presenting complaint

[a] adjusted for critical care in ED

[b] adjusted for critical care in ED and/or ICU admission

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5, fig1
		(b) Give reasons for non-participation at each stage	5, fig 1
		(c) Consider use of a flow diagram	fig1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10, table 2+3
		(b) Indicate number of participants with missing data for each variable of interest	7-10, table 2+3
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9-11, table 3
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-12, table 4
		(*b*) Report category boundaries when continuous variables were categorized	6-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.