

Factors associated with 30-day mortality in medical emergency team patients – a retrospective cohort study

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Original research

Keywords: deteriorating patient, rapid response system, rapid response team, medical emergency team, 30-day mortality, vital parameters

Posted Date: August 13th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-55388/v1>

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Abstract

Background: Medical emergency teams (METs) have been implemented to respond more efficiently to inpatient crises in order to reduce hospital mortality by the early recognition and treatment of potentially life-threatening conditions. The objective of this study was to identify factors associated with 30-day mortality risk among patients assessed by the MET.

Methods: Observational retrospective register study in a tertiary university hospital in Sweden, comprising 2,601 patients, assessed by the MET from 2010 to 2015. Patient registry data at the time of MET assessment was analysed from an epidemiological perspective, using univariable and multivariable analyses with death within 30 days as the endpoint.

Results: The overall 30-day mortality was high (29.0%) and almost twice as high on medical wards as on surgical wards (37.1% vs 19.8%). The acute medical conditions associated with the highest 30-day mortality were gastroenteritis (50.0%), acute coronary syndrome (43.0%), cardiac failure (41.1%) and renal failure (40.4%). The multivariable analysis indicated that factors with increased 30-day mortality were reflected in age, type of ward, vital parameters, laboratory findings, previous medical history and acute medical condition. Apart from age, the factor associated with the highest odds ratio for 30-day mortality was hypoglycaemia (OR 4.30 (95% CI 2.10, 8.81)).

Conclusions: We found that factors reflecting the patients' age, co-morbidity and acute medical condition, along with clinical findings such as vital parameters and laboratory abnormalities, and also the type of ward for admittance, all contributed to identifying patients at risk of death within 30 days after MET assessment. Overall, medical ward patients have higher 30-day mortality than surgical ward patients. Abnormalities in vital parameters reflecting respiratory distress appeared to be more alarming than waning circulatory functions.

Background

Over the years, healthcare has evolved rapidly with increasingly older and more ill patients being attended to, resulting in enormous demand. Rapid response systems (RRS), including medical emergency teams (MET), provide frail patients in general wards with continuous access to critical care expertise when early signs of clinical deterioration are recognised (1, 2). Despite this, intensive care resources are insufficient (3, 4). It would, therefore, be desirable to refine the selection of patients who would benefit most from admission to the intensive care unit (ICU).

The objective of this study was to identify factors associated with 30-day mortality risk among patients assessed by the MET. Patient registry data at the time of MET assessment was analysed from an epidemiological perspective, using univariable and multivariable analyses with death within 30 days as the endpoint. We believe that early identification of patients with high mortality risk can be valuable in the guidance of further therapeutic efforts and adaptation to available resources.

We hypothesised that it is possible to identify factors at the time of MET assessment associated with an increased mortality risk during the subsequent 30 days. Potential risk factors could then be considered more systematically as decision support when prioritising and optimising the early chain of care.

Methods

Settings

The study was performed at Sahlgrenska University Hospital in Gothenburg, Sweden. The hospital provides specialised care and is the trauma referral centre for the region. It has some 700 beds available for close to 50,000 admissions and 18,000 surgical procedures each year. The MET service was introduced at Sahlgrenska in 2005. Since 2007, the MET service has operated at full scale on all nursing wards, except for thoracic surgery wards, receiving approximately 600 consultation calls annually. A breakdown of the number of MET assessments versus hospital admissions is reported (*Additional file 1*).

MET system

The MET system is activated by ward staff when patients develop predefined alterations in vital parameters, or when any of the staff feels worried about the patient (5). The MET system is designed to be activated in patients with abnormal vital parameters. In the event of an immediate life-threatening condition, the cardiac arrest team (CAT) should be alerted.

During the study period, the MET service was available 24 hours/day, all week. MET included an intensive care specialist at consultant level during the day and an intensive care trainee at night, plus an intensive care nurse. The CAT service operated similarly but consisted of three doctors trained in intensive care, internal medicine and cardiology, respectively and usually an anaesthetic nurse. The MET system utilised a single-parameter track-and-trigger system, with the following activation criteria:

- Saturation <90% despite O₂
- Respiratory rate <8 or >30 breaths/minute
- Systolic blood pressure <90 mmHg
- Heart rate <40 or >130 beats/minute
- Decreased level of consciousness
- Serious concern regarding the patient's health

Until September 2013, 'threatened airway' was included as a criterion. However, due to the seriousness of this condition, it was removed to be handled by the CAT instead. During the time of the study, individual, need-based ordinations for checking vital parameters were applied. Given the immense diversity of ward

patients, a universal praxis was refrained from. Depending on clinical findings, ward nurses were delegated to administer oxygen to patients with hypoxia.

Study design

The study was conducted as a retrospective, observational study of registry data on MET assessed patients, 1 January 2010 to 31 December 2015. The outcome was 30-day mortality.

Study population

To be included, patients had to be assessed by the MET on general wards and registered in a standardised protocol. The patient had to be 18 years or older, with known 30-day survival status. In the event of repeated MET assessments, only the first MET assessment during each hospital episode was included in the main study (*Figure 1*).

To investigate whether patients requiring additional MET assessments during the same admission period differed from patients requiring only one MET assessment. These two patient groups were compared regarding age, gender and previous medical history (*Additional file 2*).

Data collection

Data were collected from the assessment protocol, supplemented with electronic medical records. Baseline characteristics, type of ward, previous medical history, the reason for MET call, vital parameters at MET arrival, laboratory markers from up to 48 hours before and 6 hours after MET activation, acute medical condition, limitation of medical therapy (LOMT), potential ICU admission and primary diagnosis were recorded. Thirty-day survival status was obtained and confirmed from the Swedish population registry (*Additional file 3*).

Statistical analysis

Logistic regression was used to calculate age-adjusted p-values for the association of each variable with 30-day mortality. Due to the amount of missing data for several of the variables, multiple imputations were used for multivariable analysis. Missing data were assumed to be missing at random (MAR) and 50 imputed datasets were generated using the Markov Chain Monte Carlo (MCMC) method using the expectation-maximisation (EM) algorithm. Rubin's rules were used to pool results from the imputed datasets. To exclude the possibility that missing data pattern was missing completely at random (MCAR), we compared cases with no missing data with incomplete cases and found several significant differences. The assumption of a MAR pattern was shown to be valid by examining the associations between the missingness of each variable with other variables. To identify independent factors associated with 30-day mortality, we started with a model including age and all variables in Tables 1-5 with an age-adjusted $p < 0.20$. Collinearity was checked by association measures between variables and by inspecting the variance inflation factor, condition index and eigenvector proportions in a multiple linear regression model, including all these candidate variables. Thresholds for collinearity were a variance

inflation factor above 5 and/or condition index above 10. Multiple logistic regression was performed in each of the 50 imputed datasets and the variable with the highest p-value in the pooled result was excluded from the model. A new regression analysis was then performed in each imputed dataset. Of the remaining variables, the one with the highest p-value in the pooled result was excluded. This procedure was repeated until all the remaining variables yielded a p-value below 0.01 in the pooled result. As a sensitivity analysis to see whether our findings were consistent without imputation, we also performed a multiple logistic regression analysis with a backward stepwise selection of variables in a similar manner and including only complete cases. Two-sided tests were used, and p-values of <0.01 were considered statistically significant. Analyses were performed using SAS version 9.4 for Windows software (SAS Institute, Cary, NC, USA).

Results

Study participants and outcome

A total number of 2,601 patients fulfilled inclusion criteria (*Figure 1*). The study population comprised patients 18 to 99 years of age (mean=65.7, SD 16.8), of which 44.3% were female. Fewer than half the patients (42.5%) were transferred to the ICU. Overall 30-day mortality was 29.0%. Patients with palliative decisions and LOMT demonstrated a significantly higher 30-day mortality (65.5%), in comparison to patients without any treatment restrictions (21.2%). There were, however, no significant differences in 30-day mortality with regards to gender or level of care (age-adjusted p=0.37 and 0.31, respectively) (*Additional file 4*).

Type of ward

Most of the patients assessed by the MET were admitted to general medicine wards, followed by general surgery and neurological wards. The highest 30-day mortality was found in geriatric wards, followed by respiratory medicine and oncology wards. Overall, there was a similar number of patients from any medical and any surgical wards. MET assessed patients on surgical wards had significantly lower 30-day mortality (*Table 1*).

Table 1 – Outcome in relation to the type of ward for patients where MET was activated while hospitalised in 2010-2015 at Sahlgrenska University Hospital

	DEATH WITHIN 30 DAYS		p#
	Yes (n=755)	No (n=1,846)	
TYPE OF WARD			

MEDICAL WARDS	423 (56.0)	718 (38.9)	<0.0001
General medicine	234 (31.0)	451 (24.4)	
Oncology	68 (9.0)	99 (5.4)	
Respiratory medicine	61 (8.1)	66 (3.6)	
Cardiology	31 (4.1)	60 (3.3)	
Rheumatology	15 (2.0)	29 (1.6)	
Geriatric	13 (1.7)	10 (0.5)	
Dermatology	1 (0.1)	3 (0.2)	
SURGICAL WARDS	230 (30.5)	929 (50.3)	<0.0001
General surgery	131 (17.4)	403 (21.8)	
Urology	27 (3.6)	194 (10.5)	
Transplantation	21 (2.8)	107 (5.8)	
Orthopaedics	11 (1.5)	64 (3.5)	
Gynaecology	14 (1.9)	54 (2.9)	
Vascular surgery	18 (2.4)	51 (2.8)	
Plastic surgery	2 (0.3)	25 (1.4)	
Ear, nose and throat	6 (0.8)	25 (1.4)	
Hand surgery	0 (0.0)	6 (0.3)	
NEUROLOGICAL WARDS*	101 (13.4)	183 (9.9)	0.004
PSYCHIATRIC WARDS	1 (0.1)	16 (0.9)	0.20

Results presented as number (percent)

** Neurological wards include neurology, spinal injury and neurosurgery patients*

Age-adjusted p-value for association with 30-day mortality

Previous medical history

The most frequently reported conditions in the patients' previous history were hypertension, cancer and lung diseases. Previous conditions associated with the highest 30-day mortality were cardiac failure, followed by haematological disease, angina pectoris and pulmonary disease. The following previous conditions were significantly associated with increased age-adjusted mortality during the subsequent 30 days: cancer, haematological disease, pulmonary disease, and liver disease. (*Table 2*).

Table 2 – Outcome in relation to previous medical history for patients where MET was activated while hospitalised in 2010-2015 at Sahlgrenska University Hospital

PREVIOUS MEDICAL HISTORY*	DEATH WITHIN 30 DAYS		p#
	Yes (n=755)	No (n=1,846)	
Cancer	276 (36.6)	502 (27.2)	0.0007
Hypertension	264 (35.0)	562 (30.4)	0.06
Angina pectoris	131 (17.4)	211 (11.4)	0.34
Myocardial infarction	93 (12.3)	163 (8.8)	0.80
Cardiac failure	120 (15.9)	171 (9.3)	0.04
Cardiac arrest	6 (0.8)	15 (0.8)	0.48
Other cardiac diseases**	199 (26.4)	349 (18.9)	0.95
Peripheral arterial disease	30 (4.0)	75 (4.1)	0.11
Stroke	82 (10.9)	167 (9.0)	0.36
Neurological disease	146 (19.4)	342 (18.5)	0.96
Haematological disease	69 (9.2)	110 (6.0)	<0.0001
Diabetes	128 (17.0)	297 (16.1)	0.77

Endocrine disease	11 (1.5)	36 (2.0)	0.35
Rheumatic disease	53 (7.0)	134 (7.3)	0.60
Pulmonary disease	228 (30.2)	389 (21.1)	0.001
Respiratory insufficiency	39 (5.2)	80 (4.3)	0.98
Gastrointestinal disease	95 (12.6)	262 (14.2)	0.36
Liver disease	81 (10.7)	175 (9.5)	0.001
Pancreatic disease	20 (2.7)	46 (2.5)	0.60
Renal disease	78 (10.3)	183 (9.9)	0.79
Skeletal disease	100 (13.3)	187 (10.1)	0.27
Psychiatric disease	18 (2.4)	96 (5.2)	0.04
Addiction	56 (7.4)	192 (10.4)	1.00

Results presented as number (percent)

** Information on previous medical history was missing for one patient who died within 30 days*

*** Including; cardiac arrhythmias, valvular heart diseases, pericardial disorders, cardiogenetic disorders or congenital heart defects, among others*

Age-adjusted p-value for association with 30-day mortality

Acute medical condition

The acute conditions most frequently associated with MET activation were sepsis and pneumonia. Acute conditions associated with the highest 30-day mortality were gastroenteritis, acute coronary syndrome, cardiac failure and renal failure. The following acute medical conditions were associated with increased age-adjusted mortality during the subsequent 30 days: cardiac failure, pneumonia and renal failure. Other infections (exemplified in the footnote), postoperative infection and other postoperative complications (exemplified in the footnote) were associated with a decreased mortality (*Table 3*).

Table 3 – Outcome in relation to acute medical condition for patients where MET was activated while hospitalised in 2010-2015 at Sahlgrenska University Hospital

DEATH WITHIN 30 DAYS

ACUTE MEDICAL CONDITION*	Yes (n=755)	No (n=1,846)	p#
Acute coronary syndrome	43 (5.7)	57 (3.1)	0.07
Cardiac failure	137 (18.2)	196 (10.8)	0.002
Pulmonary disease	73 (9.7)	110 (6.1)	0.03
Pulmonary embolism	35 (4.6)	75 (4.1)	0.67
Pneumonia	232 (30.8)	375 (20.7)	<0.0001
Sepsis	254 (33.7)	592 (32.7)	0.32
Other infection**	110 (14.6)	454 (25.0)	<0.0001
Gastroenteritis	10 (1.3)	10 (0.6)	0.10
Renal failure	82 (10.9)	121 (6.7)	0.0003
Clinically relevant haemorrhage	103 (13.7)	258 (14.2)	0.32
Postoperative infection	33 (4.4)	176 (9.7)	<0.0001
Other postoperative complications***	41 (5.4)	206 (11.4)	<0.0001
Allergic reaction/anaphylaxis	0 (0.0)	34 (1.9)	0.04##

Results presented as number (percent)

** Information on acute medical condition was missing for 1 and 33 patients in the two groups, respectively*

*** Including pancreatitis, cholecystitis, pyelonephritis, diverticulitis, peritonitis, pancytopenia, neutropenic fever, cerebral abscess or meningitis, among others*

*** Including respiratory insufficiency, pneumothorax, deep vein thrombosis, postoperative cerebral insult, hypovolemia, intestinal perforation or anastomotic leakage, among others

Age-adjusted p-value for association with 30-day mortality

Firth bias correction used for likelihood penalty

Laboratory findings

The most frequent laboratory alteration was hyperglycaemia, followed by low haemoglobin, hypoxaemia and elevated serum creatinine. Laboratory findings associated with the highest 30-day mortality were hypoglycaemia, hypernatraemia, hyperkalaemia, acidosis and hyperlactatemia. The same laboratory findings were also associated with significantly increased age-adjusted mortality, along with elevated serum creatinine and hypoxaemia (*Table 4*).

Table 4 – Outcome in relation to laboratory findings for patients where MET was activated while hospitalised in 2010-2015 at Sahlgrenska University Hospital

LABORATORY FINDINGS	DEATH WITHIN 30 DAYS		p#
	Yes (n=755)	No (n=1,846)	
pH (224/596)*			
<7.35	222 (41.8)	341 (27.3)	<0.0001
>7.45	95 (17.9)	247 (19.8)	0.74
pCO ₂ ; kPa (221/591)			
<4.6	149 (27.9)	316 (25.2)	0.18
>6.0	201 (37.6)	402 (32.0)	0.07
pO ₂ ; kPa (275/753)			
<10.0	291 (60.6)	541 (49.5)	0.002
Haemoglobin (Hb); g/l (94/169)			

<134 □ / <117 □	484 (73.2)	1,260 (75.1)	0.40
Sodium (Na); mmol/l (73/173)			
<137	302 (44.3)	744 (44.5)	0.53
>145	52 (7.6)	66 (3.9)	0.002
Potassium (K); mmol/l (78/177)			
<3.6	121 (17.9)	327 (19.6)	0.53
>4.6	177 (26.1)	257 (15.4)	<0.0001
Calcium (Ca); mmol/l (281/681)			
<1.12	129 (27.2)	289 (24.8)	0.14
>1.32	29 (6.1)	51 (4.4)	0.14
Glucose; mmol/l (281/673)			
<4.2	24 (5.1)	18 (1.5)	<0.0001
>6.3	378 (79.7)	899 (76.6)	0.84
Creatinine; µmol/l (79/187)			
>105 □ / >90 □	387 (57.2)	718 (43.3)	<0.0001
Lactate; mmol/l (288/701)			
>2.2	222 (47.5)	345 (30.1)	<0.0001

Results presented as number (percent)

** Number of patients for whom information was missing in the two groups, respectively*

Age-adjusted p-value for association with 30-day mortality

Status on arrival of MET

The most frequent abnormalities in terms of vital parameters were hypoxia and tachypnoea. Patients who presented with these findings also had the highest 30-day mortality. The following vital parameters

were associated with a significantly higher age-adjusted mortality risk during the subsequent 30 days: hypoxia, tachypnoea, tachycardia and unconsciousness (*Table 5*).

Table 5 – Outcome in relation to status on arrival of MET for patients where MET was activated while hospitalised in 2010-2015 at Sahlgrenska University Hospital

VITAL PARAMETERS	DEATH WITHIN 30 DAYS		p#
	Yes (n=755)	No (n=1,846)	
<hr/>			
POX; % (15/40)*			
<90	338 (45.7)	409 (22.6)	<0.0001
RR; breaths/min (127/434)			
<8	5 (0.8)	17 (1.2)	0.59
<30	237 (37.7)	303 (21.5)	<0.0001
SBP; mmHg (43/63)			
<90	164 (23.0)	336 (18.8)	0.06
HR; beats/min (22/36)			
<40	3 (0.4)	9 (0.5)	0.92
>130	104 (14.2)	206 (11.4)	0.001
Consciousness; RLS (160/260)			
≥4	48 (8.1)	73 (4.6)	0.0007

Results presented as number (percent)

** Number of patients for whom information was missing in the two groups, respectively*

Age-adjusted p-value for association with 30-day mortality

POX, pulse oximetry; RR, respiratory rate; HR, heart rate; SBP, systolic blood pressure; RLS, reaction level scale

Independent factors associated with mortality

No important collinearity was found among candidate variables for association with 30-day mortality in the multivariable analysis. When using multiple imputations, age, type of ward, vital parameters, laboratory findings, previous medical history, and acute medical condition all contributed to the prediction of death. Apart from age, the factors with the highest odds ratio for death within 30 days were hypoglycaemia, haematological disease and hypoxia (*Table 6*).

Table 6 – Multivariable analysis of factors associated with 30-day mortality for patients where MET was activated while hospitalised in 2010-2015 at Sahlgrenska University Hospital, using multiple imputations

	OR (95% CI)	p
AGE (per year)	1.045 (1.038,1.053)	<0.0001
TYPE OF WARD		
Surgical wards	0.42 (0.34,0.51)	<0.0001
VITAL PARAMETERS		
POX <90 %	2.12 (1.72,2.61)	<0.0001
RR >30 breaths/min	1.69 (1.34,2.13)	<0.0001
RLS ≥4	1.92 (1.25,2.93)	0.003
LABORATORY FINDINGS		
Sodium >145 mmol/l	1.91 (1.23,2.96)	0.004
Potassium >4.6 mmol/l	1.50 (1.17,1.92)	0.001
Glucose <4.2 mmol/l	4.30 (2.10,8.81)	<0.0001
Lactate >2.2 mmol/l	1.71 (1.32,2.22)	<0.0001
PREVIOUS MEDICAL HISTORY		

Cancer	1.73 (1.40,2.13)	<0.0001
Haematological disease	2.45 (1.71,3.50)	0.0001
Liver disease	1.89 (1.36,2.61)	0.0001

ACUTE MEDICAL CONDITION

Renal failure	1.71 (1.22,2.38)	0.002
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755 (29.0%) endpoints of 2,601 patients

OR, odds ratio; CI, confidence interval; POX, pulse oximetry; RR, respiratory rate; RLS, reaction level scale

The timing of death in relation to days after MET assessment

In order to illustrate in more detail the time of death after MET assessment, cumulative mortality curves for the thirteen factors independently associated with 30-day mortality (*Table 6*) are presented (*Additional file 5*). Overall, approximately half of the deaths occurred within the first four days after MET assessment (*Figure 2*).

Discussion

The three main findings in this study were that (1) overall mortality among patients triggering the RRS was high. More than one out of four patients died within 30 days, and the higher the age, the greater the mortality, independent of gender. (2) The previous and acute medical conditions of patients, such as haematological disease, liver disease, cancer and renal failure, were independently and significantly associated with increased 30-day mortality. (3) The laboratory findings corresponding to the highest mortality risk were hypoglycaemia, hyperlactatemia, hypernatremia and hyperkalemia. In addition, this study implied the importance of several other factors associated with mortality in clinically deteriorating patients, including abnormal vital parameters such as hypoxia and tachypnoea, level of consciousness and type of ward activating the RRS.

The noticeably high mortality rate in this MET population could be explained by the possibly life-threatening situation of clinical deterioration in combination with advanced age and numerous co-morbidities. As stated in previous studies, MET patients are in the poorest condition among hospitalised patients with high in-hospital and 30-day death rates (1, 6). Analogously, the type of ward demonstrating by far the highest risk of death among admitted patients was the geriatric wards. More than half of the clinically deteriorated geriatric patients triggering the MET died within 30 days after assessment. Given the indisputable importance of age in relation to survival, the potentially beneficial contribution of the patient's age as a trigger component in the early warning system cannot be ignored.

The association between type of ward and mortality reflects the commonly found medical conditions. It appears that medical and surgical wards tend to utilise the RRS to about the same extent, although the difference in outcome was striking in our study. The overall 30-day mortality on medical wards was almost twice as high as that on surgical wards. Consequently, the patient's place of care may be indicative of the end of the course, in terms of mortality, as medical ward patients proved to have a significantly increased risk of death. Thus, the opposite proved to be true for surgical ward patients. The difference in 30-day mortality between surgical and medical ward patients could be explained in part by the fact that surgical patients tended to have less co-morbidity and more of an isolated problem (*Additional file 6*).

The difference in outcome regarding the patient's place of care is further reflected when analysing the patient's previous and acute medical conditions with 30-day mortality. The most aggravating previous history was primarily internal medicine diseases, such as cardiac failure, haematological disease, angina pectoris and pulmonary disease. Correspondingly, the acute medical conditions associated with the highest 30-day mortality were predominantly internal medicine diseases, such as gastroenteritis, acute coronary syndrome, cardiac failure and renal failure. Surgically related conditions, such as postoperative infection and other postoperative complications, were significantly associated with lower mortality risk. The common denominator among the surgical patients appeared to be a transient or reversible illness with a good prognosis when treated correctly.

The most frequently used trigger criterion was POX <90% (*Additional file 7*). Interestingly, the incidence of POX <90% decreased by almost 10 per cent units between MET activation and arrival (*Table 5*), which is believed to depend on the general delegation of oxygen administration issued to the ward nurses and possibly also oxygen treatment recommendations over the phone pending the arrival of the MET. Despite this initial sign of improved optimisation, hypoxia and tachypnoea were associated with the highest 30-day mortality among vital parameters, which strengthens the findings in previous studies (7). Curiously, circulatory parameters did not play as important a role in predicting outcome in the MET patient population.

Caution should be taken concerning the fact that one of the vital parameters of the utmost importance in predicting 30-day mortality, i.e. the respiratory rate, was the parameter least often measured by the MET – missed in more than every fifth patient. Considering the significant mortality risk when a patient presents with tachypnoea, we call for more attention to be paid to monitoring this vital parameter (8-10).

Despite hypoglycaemia being the most rarely encountered abnormal laboratory finding, it was associated with the highest mortality risk of all measured risk factors. It is worth noting that numerous studies have shown that hyperglycaemia is strongly associated with increased morbidity and mortality, e.g. in acute coronary syndrome, in admitted patients, regardless of whether or not they were diagnosed with diabetes mellitus (11, 12). Nonetheless, our finding is also well-founded in the literature, where hypoglycaemia has been shown in several studies to be an independent risk factor for death in patients with acute illness (13-15). Hence, it appears that disturbances in glucose metabolism, regardless of direction, signify an

increased risk of adverse outcomes among critically ill patients. Other laboratory findings associated with poor outcome were hyperlactatemia, hypernatraemia, hyperkalaemia, acidosis, hypoxaemia and elevated creatinine. Apart from creatinine, all the mortality-indicative laboratory values are found in regular blood gas analyses. Our data, however, revealed that arterial blood gases were missing during the care event for 40% of the patients, which leads us to speculate about whether more frequent blood gas sampling in clinically deteriorating patients would be beneficial for the early detection of severe illness and, by extension, improved outcome.

In order to demonstrate independent associations of epidemiological factors in the MET patient population, multivariable analyses were performed. Due to the large quantity of included variables, more than half the study population was excluded from the complete data analysis, as a result of missing data on one or more of these variables (*Additional file 8*). Therefore, a multivariable analysis using multiple imputations was performed (*Table 6*). Regardless of the method, the results of both multivariable analyses were consistent with those of the analyses of each variable separately. As previously indicated, hypoglycaemia proved to be a major risk factor for death within 30 days, followed by, among several others, haematological disease and hypoxia. Again, attendance on surgical wards was a favourable factor of reduced mortality.

Clinical implications

Medical ward patients have a higher risk of death within 30 days than surgical ward patients. Abnormalities in vital parameters reflecting respiratory distress appear to be more alarming than waning circulatory functions. Altogether, the elderly MET patients, patients admitted to medical wards and patients presenting with abnormal respiratory function or renal failure, and patients with a history of haematological disease, liver disease or cancer have the highest risk of death within 30-days. For this reason, reducing the threshold for intensive care among these patient groups may be beneficial from a survival point of view, provided that no LOMT are applied. Factors associated with mortality emanate from many diverse sources. Using a standardised risk score system at MET assessment as a basis for estimation of the mortality risk should, therefore, be favourable from a prioritisation and optimisation perspective.

Study strengths and limitations

Strengths: the study was population-based with well-defined inclusion and exclusion criteria and a relatively large sample size. Furthermore, it was consecutive, and all cases were evaluated for inclusion. Moreover, it was chart based, with all cases handled manually.

Limitations: data were limited to 2010-2015, and new conditions may have emerged since then. The 'MET dose', calculated as the number of MET assessments divided by the number of hospital admissions (approximately 12/1,000), was low in comparison to studies in other healthcare systems, possibly indicating an inefficiency in the system (16). Despite this, our 'MET dose' is higher than the dose previously reported in a before-and-after trial in Sweden, where the implementation of MET was

associated with a significant improvement in cardiac arrest rate and in-hospital mortality (17). Given the retrospective design, it was not possible to check and correct for afferent limb failure, i.e. delayed activation of the MET (18). Further, it was a single-centre study using a single-parameter system, not fully transferable to hospitals with different routines. Since it was a retrospective study, we were not able to control for unmeasured factors. Also, for several of the variables, the number of missing data was substantial, although we tried to handle this by using multiple imputation methods in the multivariable analysis. In a retrospective register study, it is not possible to draw any conclusion regarding the cause and the effect. We are only able to describe associations.

Conclusions

The MET population remains an exposed category amongst hospitalised patients. The overall 30-day mortality was 29.0%. We found that factors reflecting the patients' age, co-morbidity and acute medical condition, along with clinical findings such as abnormal vital parameters and laboratory abnormalities, and also the type of ward for admittance, all contributed to identifying patients at risk of death within 30 days after MET assessment.

Declarations

Funding

The study was supported by grants from the Swedish state under the agreement between the Swedish government and the county councils (the ALF agreement: ALF GBG-716901, ALF GBG-74200), the Swedish Heart and Lung Foundation and the Gothenburg Medical Society.

Acknowledgement

Jonny Lindqvist, at the Center of Registers in Västra Götaland, Sweden, for his computer skills and invaluable support with the database.

Availability of data and materials

are available from the corresponding author on request

Authors' contributions

All authors have directly participated in the planning and implementation of the study, and in the analyses and interpretation of data. All authors have read and approved the final version of the submitted manuscript. There are no related manuscripts or abstracts, published or unpublished, by any of the authors of this paper.

Detailed author contribution	AA	CD	PF	TK	LP	JH	SL
Study concept and design	X	X	X	X	X	X	X
Acquisition of data	X	X	X		X		
Analysis and interpretation of data	X	X	X	X	X	X	X
Drafting of the manuscript	X			X			
Critical revision of the manuscript for important intellectual content						X	X
Obtained funding	X					X	X
Administrative, technical, or material support		X				X	X
Study supervision						X	X

Competing interest

The authors declare that they have no competing interests, including non-financial competing interests.

Ethics approval

Approval was obtained from the ethical review board at the University of Gothenburg, Sweden, 2014-05-12, reference number 096-14. The committee waived the need for informed consent due to the retrospective nature of the study and the fact that many of the participants would be incapacitated or deceased.

Consent for publication

NA

Abbreviations

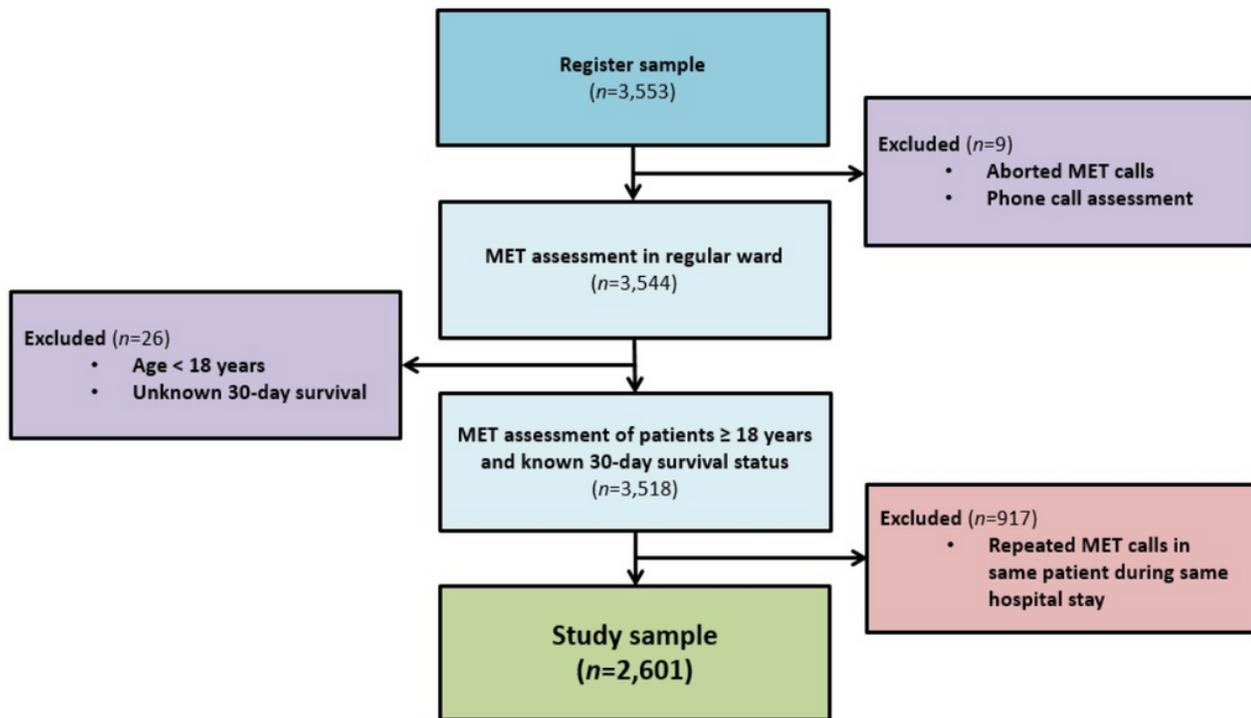
RRS: Rapid response systems; MET: Medical emergency teams; ICU: Intensive care unit; CAT: Cardiac arrest team; MAR: Missing at random; MCMC: Markov Chain Monte Carlo; EM: Expectation-maximisation; MCAR: Missing completely at random; SD: Standard deviation; OR, 95% CI: Odds ratios with 95% confidence intervals; LOMT: Limitations of medical therapy.

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Figures



MET: medical emergency team; ICU: intensive care unit

Figure 1

Flow chart of study participants; Register sample of patients where MET was activated while hospitalised in 2010-2015 at Sahlgrenska University Hospital.

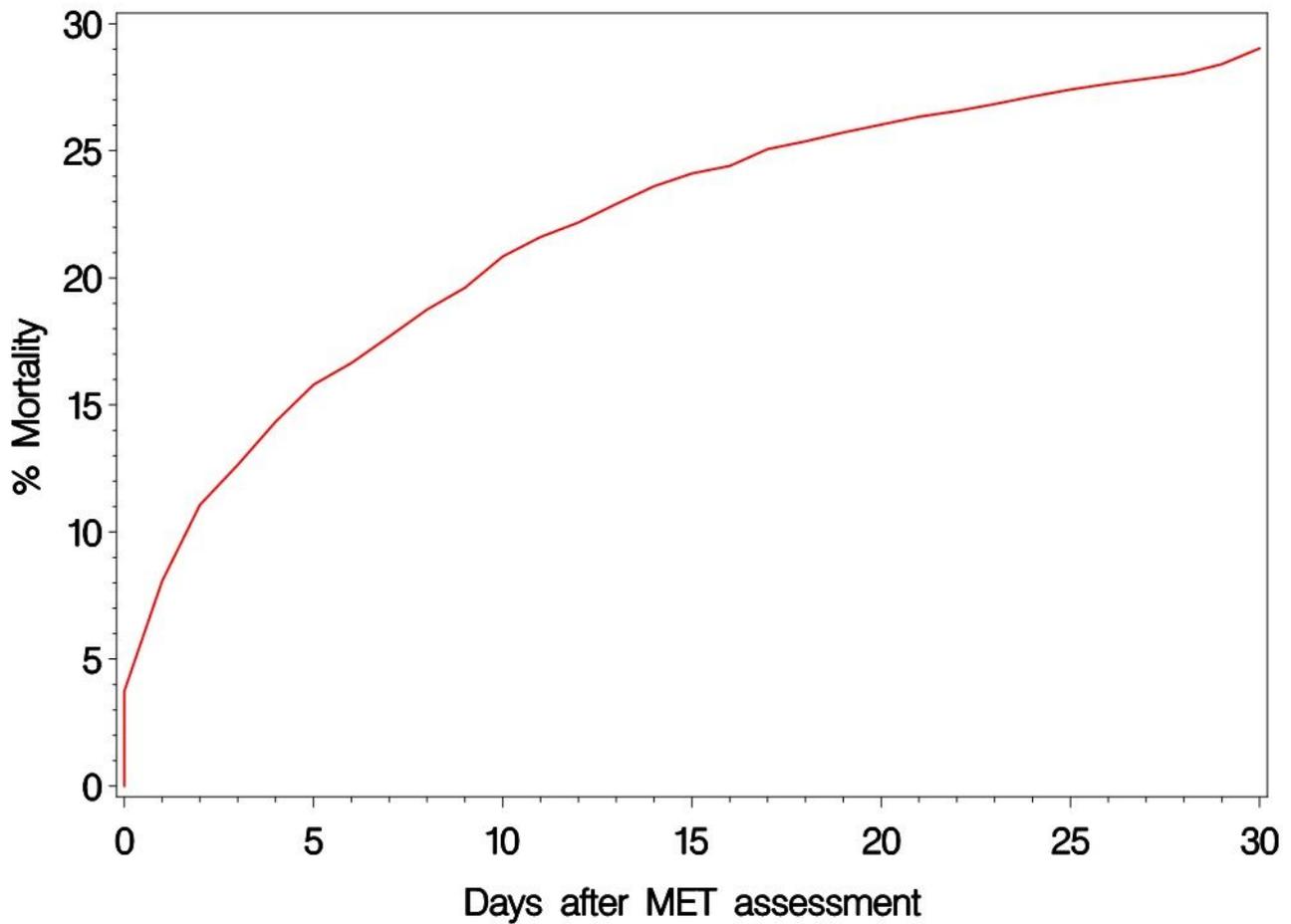


Figure 2

Timing of death in relation to days after MET assessment while hospitalised in 2010-2015 at Sahlgrenska University Hospital.

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