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Original Article

Breaches of pre-medical emergency team call criteria in an Australian hospital

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ABSTRACT

Objectives and outcomes: To evaluate the 24hrs before medical emergency team (MET) calls to examine: 1) the frequency, nature, and timing of pre-MET criteria breaches; 2) differences in characteristics and outcomes between patients who did and didn't experience pre-MET breaches.
Design: Retrospective observational study November 2020–June 2021.
Setting: Tertiary referral Australian hospital.
Participants: Adults (≥18 years) experiencing MET calls.
Results: Breaches in pre-MET criteria occurred prior to 1886/2255 (83.6%) MET calls, and 1038/1281 (81.0%) of the first MET calls. Patients with pre-MET breaches were older (median [IQR] 72 [57–81] vs 66 [56–77] yrs), more likely to be admitted from home (87.8% vs 81.9%) and via the emergency department (73.0% vs 50.2%), but less likely to be for full resuscitation after (67.3% vs 76.5%) the MET. The three most common pre-MET breaches were low SpO_2 (48.0%), high pulse rate (39.8%), and low systolic blood pressure (29.0%) which were present for a median (IQR) of 15.4 (7.5–20.8), 13.2 (4.3–21.0), and 12.6 (3.5–20.1) hrs before the MET call, respectively. Patients with pre-MET breaches were more likely to need intensive care admission within 24 h (15.6 vs 11.9%), have repeat MET calls (33.3 vs 24.7%), and die in hospital (15.8 vs 9.9%).
Conclusions: Four-fifths of MET calls were preceded by pre-MET criteria breaches, which were present for many hours. Such patients were older, had more limits of treatment, and experienced worse outcomes. There is a need to improve goals of care documentation and pre-MET management of clinical deterioration.

1. Introduction

Rapid Response Systems (RRSs) have been introduced into hospitals to improve the recognition of, and response to clinical deterioration in hospital wards.[1] In Australia, the responding team (or efferent arm) of the RRS is typically a physician-led Medical Emergency Team (MET).[2,3] The introduction of METs have been associated with decreased in-hospital cardiac arrests and mortality amongst hospital ward patients.[4–7]

Despite such improvements, patients who are reviewed by the MET in Australia are an at-risk population, as at least 10% are admitted to ICU, and approximately 20% die during the same hospital admission.[8] In response to these observations, many hospitals have implemented a pre-MET tier to enhance recognition and response earlier in the trajectory of deterioration.[9–12] In Australia, this is most frequently a single parameter system with activation

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criteria less extreme than for the MET, and the responding team is usually the treating team and/or senior ward nurses instead of ICU clinicians.[13–17]

The principle behind the pre-MET tier is that the usual treating team can review the patient earlier in the trajectory of clinical deterioration. Such review may avert progression to MET criteria, thereby leading to further improvements in patient outcomes.[11,13,15,18]

At the Austin hospital, the pre-MET tier is referred to as Urgent Clinical Review (UCR). Previous studies conducted in our hospital have examined the frequency, nature, and timing of pre-MET criteria breaches,[9] and characteristics and outcomes of patients receiving pre-MET reviews.[19] However, these studies were performed between 2014 and 16, within two years of the implementation of UCR, and included only 200 and 50 patients, respectively. It is possible that these findings may have changed, as the UCR process has matured. Only one study has compared the epidemiology and outcomes for patients with and without pre-MET deterioration.[20]

Accordingly, we conducted a detailed analysis of MET calls to examine the frequency, nature, and timing of pre-MET criteria breaches in the prior 24hr. In addition, we evaluated the differences in demographics and outcomes for those MET patients who did and did not experience pre-MET breaches.

2. Methods

2.1. Design and setting

We conducted a single-centre retrospective observational study. The study period was November 2020 to June 2021 to minimise confounding due to the peak waves of hospital admissions related to the COVID-19 pandemic in Victoria. The Austin hospital is a tertiary referral university-affiliated hospital with 560 acute care beds. It is the state referral centre for liver transplantation, spinal cord injury, complex ventilatory weaning, toxicology, and complex aortic cardiac surgery.

2.2. Ethics approval

We obtained approval for this low-risk study from the hospital research ethics committee (Austin/21/Audit/91). The need for informed written patient consent was not required due to the retrospective audit and de-identified nature of the study.

2.3. Details of emergency medical responses

The hospital has a three-tiered RRS.[9,10,21] The first tier is a Respond Blue call, which is activated for immediate life-threatening emergencies including cardiac and respiratory arrest. The second tier is a physician-led MET which is led by staff from the intensive care unit (ICU).[22–24] At the end of each MET call, the ICU registrar completes an electronic note on the call, which populates an electronic database. The third response is a pre-MET tier, referred to as UCR, which was introduced in 2012.[9,10,21] A UCR call is activated when patients breach pre-defined criteria, which are less extreme than those of the MET. The responding clinician is from the usual treating team, who must respond within 30 min. The calling criteria, expected response times, and responding teams are presented in Appendix 1 and have been published in further detail elsewhere.[21] All vital signs are entered into an electronic health record. If abnormal vital signs are documented, nurses receive visual alerts to respond according to the relevant RRS pathway.

2.4. Participants

We included all adult (≥18 years) patients who were reviewed by the hospital MET during the study period. Patients were excluded if the emergency call occurred in the Mental Health Precinct (where different calling criteria and responses occur).

2.5. Details of variables collected

We collected demographic information from the hospital clinical informatics system including age, gender, usual place of residence, the presence of co-morbidities needed to calculate the Charlson co-morbidity index,[25] and the nature of the treating team the patient was admitted under (medical, surgical, other). Details of the MET call included the day and time of the call, the reason the call was activated (Appendix 1), and the presence of limitations of medical treatment (LOMT) both before and after the MET call. These are characterised as “For full care”; “Not for Respond blue, but for MET call”, or “Not for Respond blue or MET call”.

We then evaluated the electronic health record to document whether the patient had vital signs that breached pre-MET criteria in the prior 24hr. Specifically, we recorded the total number of vital sign breaches, along with the timing of the first pre-MET breach, as well as the timing of the pre-MET breach closest to the occurrence of the MET call. Finally, we recorded whether the patient was admitted to the ICU within 24hr of the MET call, the need for repeat MET call, in-hospital length of stay, and in-hospital mortality.

2.6. Outcome measures

The primary outcome measure was the proportion of patients with pre-MET criteria breaches in the 24 h before patients are reviewed by the MET (primary outcome). A breach was deemed to have occurred when the patient had vital signs that fulfilled or exceeded the criteria for pre-MET tier activation.

The secondary outcomes included: the frequency, nature and timing of each pre-MET breach during this 24hr period. The tertiary outcome was the differences in baseline characteristics and outcomes for MET patients who experience pre-MET breaches, compared with those who do not.

2.7. Statistical methods

Categorical data are presented as counts (%) and distributed data as median (IQR). Differences in proportions are compared using Fisher's exact test, and differences in distributed data with the Mann–Whitney U test. A two-sided p-value of <0.05 was taken to indicate statistical significance.

In instances where patients had two or more MET calls, we used the first MET call to compare differences in the characteristics and outcomes for patients who had pre-MET criteria breaches, compared with those who did not. The rationale for this approach was that once a patient breaches the MET criteria, it is highly likely that they will subsequently breach less extreme pre-MET criteria.

3. Results

3.1. Details of MET calls and patients

Between November 2020 and June 2021, there were 2255 MET calls, of which 919 (40.8%) involved females. The six most common reasons for MET activation were high heart rate (24.3%), low blood pressure (22.8%), high respiratory rate (19.9%), low oxygen saturations (7.5%), staff worried (6.8%), and change in conscious state (6.7%) (Appendix 2).

Table 1
Patient demographics and details of MET calls for patients who breached Pre-MET criteria in the prior 24hr, compared with those who did not.

Variable	Total population	Pre-MET breaches in prior 24hr	No pre-MET breaches in prior 24 h
Number of patients	1281	1038	243
Age; median (IQR) years[a]	71.0 (57.0–81.0)	72.0 (57.0–81.0)	66.0 (56.0–77.0)
Female gender; N (%)	545 (42.5)	452 (43.6)	93 (38.3)
Charlson co-morbidity index; median (IQR)[a]	5.0 (3.0–7.0	5.0 (4.0–7.0)	5.0 (3.0–7.0)
Type of admission; N (%)			
Medical	783 (61.1)	640 (61.6)	143 (58.9)
Surgical	488 (38.1)	390 (37.6)	98 (40.3)
Other	10 (0.8)	8 (0.8)	2 (0.8)
Admission source; N (%) [a]			
Home	1110 (86.7)	911 (87.8)	199 (81.9)
Other hospital	112 (8.7)	77 (7.4)	35 (14.4)
Nursing home	49 (3.8)	44 (4.2)	5 (2.1)
Other	10 (0.8)	6 (0.6)	4 (1.7)
Admitted via ED; N (%)[a]	880 (68.7)	758 (73.0)	122 (50.2)
ED LOS; median (IQR) hr	7.7 (5.0–11.9)	7.8 (5.1–11.8)	7.2 (4.1–13.0)
MET call trigger; N (%) [a]			
High heart rate	304 (23.8)	253 (24.4)	51 (21.0)
Low blood pressure	281 (21.9)	235 (22.6)	46 (18.9)
High respiratory rate	238 (18.6)	213 (20.4)	25 (10.3)
Worried	103 (8.0)	74 (7.1)	29 (11.9)
Low oxygen saturation	98 (7.7)	83 (8.0)	15 (6.2)
Change conscious state	84 (6.6)	57 (5.5)	27 (11.1)
Other	173 (13.5)	123 (11.8)	50 (20.6)
MET on weekday; N (%)	931 (72.7)	745 (71.8)	186 (76.5)
Time of day; N (%)			
In-hours	577 (45.0)	453 (43.6)	124 (51.0)
Evening	370 (28.9)	309 (29.8)	61 (25.1)
Overnight	334 (26.1)	276 (26.6)	58 (23.9)
MET call from admission[a]	48 (14–136)	46 (14–127)	64 (18–193)
Median (IQR) hours			
LOMT pre-MET call; N (%) [a]			
Full care	908 (70.9)	720 (69.4)	188 (77.4)
Not for RB	350 (27.3)	300 (28.9)	50 (20.6)
Not for RB or MET	23 (1.8)	18 (1.7)	5 (2.1)
LOMT post-MET call; N (%) [a]			
Full care	885 (68.1)	699 (67.3)	186 (76.5)
Not for RB	331 (25.8)	286 (27.6)	45 (18.5)
Not for RB or MET	65 (5.1)	53 (5.1)	12 (4.9)

RB = respond blue call, MET = medical emergency team; IQR = inter-quartile range; LOMT = limitation of medical treatment.
[a] Indicates $p < 0.05$.

The 2255 MET calls occurred in 1281 patients. Thus, 875 patients had one call, 254 had two calls, 77 had three calls, 35 had four calls, and 40 patients had five or more calls during the study period. Patient demographics for the 1281 patients and details of the first MET call are outlined in Table 1.

Of the 2255 MET calls, 594 (26.3%) occurred on the weekend. In addition, MET calls occurred in-hours (08:00–18:00), during the evening (18:01–24:00), and overnight in 45.2%, 27.4% and 27.4% of instances, respectively. A total of 202 (9.0%) MET calls were associated with immediate transfer to the ICU, and 406 (18.0%) were associated with ICU transfer within 24hr of the MET call.

3.2. Details of baseline demographics and MET calls according to pre-MET criteria

Amongst the 2255 MET calls there was a breach of pre-MET criteria in 1886 (83.6%) in the prior 24hr. Similarly, amongst the 1281 initial MET calls, 1038 (81.0%) had breaches in pre-MET criteria in the prior 24hr.

Patients who had a documented pre-MET breach in the prior 24hr were on average six years older and more likely to be admitted from the emergency department. There were also differences in the source of admission and primary trigger for the MET call, especially in relation to increased respiratory rate (Table 1). There were no differences in the timing of MET call activation according to antecedent pre-MET breaches. However, patients who experienced a preceding pre-MET breach were more likely to have LOMTs both before and after the call, and had their first MET call on average 18 h earlier in the hospital admission (Table 1).

3.3. Details of antecedent pre-MET criteria

Details of the frequency, nature, and timing of pre-MET breaches in relation to the MET call are shown in Table 2, along with the median value of the vital signs for the documented breach. Some patients breached more than one criterion in the 24hr period, and also breached the same criterion more than once. Despite hypoxia being the trigger for only 7.7% of MET calls, almost 50% of patients breached the pre-MET criteria for low oxygen saturation in the preceding 24hr. The median value for respiratory rate was 28 breaths per minute, which exceeds the MET criteria for this vital sign.

3.4. Differences in outcomes according to the presence of pre-MET breaches

There were important clinical and statistically significant differences between patients who experienced a pre-MET breach in the 24hr prior to the initial MET call, compared with those who did not (Table 3). In particular, pre-MET breach patients were

Table 2
Details of the frequency of Pre-MET breaches, median vital sign value, and time between pre-MET breach and MET call.

	Frequency of breach; N (%)[a]	Value median (IQR)	Time between breach and MET call; median (IQR) hr
Earliest Pre-MET breach			
Pulse rate high	510 (39.8)	109.0 (104.0–118.0)	13.2 (4.3–21.0)
Pulse rate low	49 (3.8)	42 (24.0–46.0)	12.7 (5.8–20.4)
Respiratory rate high	348 (27.2)	28.0 (26.0–31.0)	10.8 (1.1–19.3)
Respiratory rate low	14 (1.1)	6.0 (1.0–8.0)	7.1 (1.0–15.4)
SpO_2	615 (48.0)	94.0 (92.0–94.0)	15.4 (7.5–20.8)
SBP high	70 (5.5)	187.0 (184.0–199.0)	9.6 (3.0–17.4)
SBP low	371 (29.0)	94.0 (90.0–97.0)	12.6 (3.5–20.1)
Temperature high	229 (17.9)	38.3 (38.1–38.6)	11.3 (3.4–19.1)
Temperature low	121 (9.5)	35.4 (35.1–35.5)	14.1 (8.2–18.6)
Most recent Pre-MET breach			
Pulse rate high	511 (39.9)	109.0 (104.0–120.0)	1.8 (0.4–7.4)
Pulse rate low	48 (3.8)	42.0 (35.0–46.0)	3.2 (0.7–14.2)
Respiratory rate high	345 (26.9)	28.0 (26.0–31.0)	1.1 (0.2–8.1)
Respiratory rate low	17 (1.3)	6.0 (1.0–8.0)	3.4 (0.9–9.1)
SpO_2	615 (48.0)	93.0 (91.0–94.0)	3.4 (0.7–9.3)
SBP high	66 (5.2)	188.0 (184.0–195.0)	5.7 (0.8–13.0)
SBP low	375 (29.3)	93.0 (88.0–97.0)	2.1 (0.3–9.2)
Temperature high	231 (18.0)	38.3 (38.1–38.6)	3.0 (0.5–10.7)
Temperature low	119 (9.3)	35.4 (35.2–35.5)	11.8 (6.0–16.7)

MET = medical emergency team; IQR = inter-quartile range; hr = hours; SBP = systolic blood pressure; SpO_2 = saturation oxygen.
Units of measurement: Pulse rate = beats per minute; Respiratory rate = breaths per minute; SpO_2 = percentage; SBP = mmHg; Temperature = degrees Celsius.
[a] Patients may have breached more than one criterion in the prior 24hr and breached the same criteria on more than one occasion.

more likely to be admitted to the ICU following the MET, and within 24hr of the MET occurring. In addition, patients who experienced a pre-MET breach in the prior 24hr before their first MET call were more likely to have repeat MET calls in the same hospital admission, and to die during that hospital admission (Table 3). The increased risk of death was mostly seen in the patients who did not have LOMTs at the completion of the MET call (Table 3).

4. Discussion

4.1. Summary of major findings

We conducted a retrospective study of 1281 patients who experienced a MET call and found that four-fifths of patients breached pre-MET criteria for escalation in the prior 24hr. Compared with patients who did not breach pre-MET criteria, such

Table 3
Differences in outcomes for patients who breached pre-MET criteria in the prior 24hr, compared with those who did not.

Variable	Total population	Pre-MET breaches in prior 24hr	No Pre-MET breaches in prior 24 h
Total number	1281	1038	243
Immediate MET outcome; N (%)			
Remained on current ward	1134 (88.5)	915 (88.2)	219 (90.1)
Transfer ICU	69 (5.4)	59 (6.7)	10 (4.1)
Transfer HDU	20 (1.6)	17 (1.6)	3 (1.2)
Transfer to other ward	21 (1.6)	16 (1.5)	5 (2.1)
Transfer to CCU	10 (0.8)	8 (0.8)	2 (0.8)
Transfer to OR	8 (0.6)	7 (0.7)	1 (0.4)
Died during MET	5 (0.4)	5 (0.5)	0 (0)
Other	14 (1.1)	11 (1.1)	3 (1.2)
Admitted to ICU within 24hr of MET; N (%)	191 (14.9)	162 (15.6)	29 (11.9)
Multiple MET calls same admission; N (%)[a]	406 (31.7)	346 (33.3)	60 (24.7)
Hospital length of stay; median (IQR) hours	264 (137–646)	280 (114–789)	263 (139–605)
Discharge destination; N (%) [a]			
Rehabilitation/placement	132 (10.3)	94 (9.1)	38 (15.6)
Died in hospital	119 (9.3)	101 (9.7)	18 (7.4)
Other hospital	69 (5.4)	49 (4.7)	20 (8.2)
Nursing home	33 (2.6)	30 (2.9)	3 (1.2)
Home	857 (66.9)	700 (67.4)	157 (64.4)
Other	71 (5.5)	64 (6.2)	7 (2.9)
Died during hospital stay; N (%)[a]	188 (14.7)	164 (15.8)	24 (9.9)
Hospital mortality and LOMT			
Full care	71/885 (8.0)	64/699 (9.2)	7/186 (3.8)
Not for RB	76/331 (23.0)	67/286 (23.4)	9/45 (20.0)
Not for RB or MET	41/65 (63.1)	33/53 (62.3)	8/12 (66.6)

MET = medical emergency team; IQR = inter-quartile range; hr = hours; ICU = intensive care unit; HDU = high dependency unit; LOMT = limitation of medical treatment.
[a] Indicates $p < 0.05$.

patients were older, more likely to be admitted from the ED and to have a MET call for respiratory distress. They were also more likely to have limitations of medical treatment, to experience repeat MET calls, to require ICU admission, and to die during the hospital admission.

4.2. Comparison with previous studies

To our knowledge, only one previous study has evaluated the frequency and nature of pre-MET criteria breaches, which was done in the same hospital. Sprogis and co-workers similarly found that 78.5% of 200 MET calls breached pre-MET criteria in the prior 24hr and that hypoxemia was a common reason for such breaches[9] Two recent studies from our hospital revealed that there were multiple barriers to interdisciplinary communication and optimal use of the pre-MET tier for clinical escalation.[26,27] The sub-optimal use of the pre-MET tier may explain the high frequency of pre-MET breaches in our hospital. This may be a result of delays in the initial activation of the pre-MET call, or the timeliness or effectiveness of the response.

Tan and co-workers have recently reported on the differences in characteristics and outcomes of patients experiencing pre-MET activations.[20] This study differed from ours in that it evaluated how often patients receiving a pre-MET review went on to have MET calls, rather than how often patients experiencing MET calls had breaches of pre-MET criteria.

4.3. Studies strengths and limitations

We have conducted a large cohort study to describe in detail the frequency and nature of pre-MET criteria breaches, along with differences in the baseline characteristics and outcomes of patients who experienced pre-MET breaches compared with those who did not. Despite these strengths, our study has the limitations of single-centre and retrospective study with the limitations inherent to this design. In addition, we were unable to adjust for confounders in the outcome measures. We are not able to comment on the frequency of actual assessment by the parent unit clinicians, nor on the interventions that might have been provided prior to the MET occurring. Thus, we cannot comment on the number of patients on whom clinicians conducted a review within 30min of the pre-MET breach. Previous research suggests that clinicians uncommonly utilise the pre-MET tier in the way it is presented in hospital policy. Thus, the effect of pre-MET interventions on patient outcomes remains uncertain.[26,27] Finally, the study was conducted during the COVID pandemic, which may have potentially increased the proportion of patients who triggered the respiratory rate and hypoxemia triggers. However, we note that the previous study performed in 2014 also identified hypoxemia as a frequent trigger of pre-MET tier activation.[9]

4.4. Implications for clinicians and policy makers

We found that a high proportion of MET calls were preceded by clinical deterioration breaching pre-MET criteria. Such patients had a higher proportion of LOMTs, a greater frequency of recurrent MET calls, and an increased in-hospital risk of death. The increased risk of death was mostly seen in the patients who did not have LOMTs at the completion of the MET call. Combined, these findings suggest that there may be opportunities to identify and manage clinical deterioration in the period prior to MET calls, and to also improve goals of care setting and end-of-life care discussions.

We also found that whilst hypoxemia was a common pre-MET criteria breach, this was not a common trigger for MET calls. This may be due to the current pre-MET criterion for low oxygen saturation at our hospital ($SpO_2 \leq 94\%$). Reducing the threshold to trigger this criterion may reduce potentially unnecessary pre-MET calls.[9]

4.5. Areas for future research

There is a need to further study the pre-MET tier of RRSs. In particular, we intend to develop and evaluate systems and processes to capture the timing and frequency of pre-MET activation, along with the timeliness of clinical response, and the nature of interventions provided during the pre-MET review. Such processes would allow us to identify how often patients are reviewed within 30min of a pre-MET tier breach, and to evaluate the effectiveness of any interventions provided.

5. Conclusions

Approximately four-fifths of MET calls are preceded by objective signs of clinical deterioration, which are present for many hours prior to MET activation. Improving the process of escalation, review, and documentation of pre-MET activation, along with enhancing goals of care discussions may avert MET calls, and further improve patient outcomes.

CRediT authorship contribution statement

DJ conceived the study, based on the prior study of SS; GE and DJ oversaw ethics and governance processes; KS did data extraction; KS, NG and DJ conducted the analysis. All authors contributed to drafting and revision of the manuscript.

Conflict of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Their are no conflicts of interest to declare If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ccrj.2023.11.002.

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