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Clinical paper

Changing patterns in paediatric medical emergency team (MET) activations over 20 years in a single specialist paediatric hospital

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ABSTRACT

Background: The Medical Emergency Team (MET) model was first introduced in the early 1990s and aimed to intervene at an earlier stage of patient clinical deterioration. This study aimed to describe the changes in patient demographics, patterns of activation and clinical outcomes of MET activations at our specialist paediatric hospital across a 20-year period providing the longest duration Medical Emergency Team data set published to date.

Methods: This single-centre observational study prospectively collected data about MET events at a single specialist paediatric hospital in Australia from 1995 to 2014. Patient demographics, activation patterns and clinical outcomes from MET activations were analysed for the 20-year period.

Results: 771 MET events were included in analysis. Most MET events involved children aged <5 years (median age 36 months) with decreased incidence on weekends and night shift. The most frequent reasons stated for MET activation were seizure and respiratory compromise and the most commonly recorded MET interventions were bag-valve-mask ventilation and intravascular access. There was an increase in MET event frequency (MET events per 1000 hospital separations) in the second decade of the service compared to the first (3.25 vs 1.42, $p < 0.001$) with fewer events for cardiopulmonary arrest but more for respiratory, cardiovascular or neurological compromise.

Conclusions: This study describes the longest duration MET data set published to date. The 20-year span of data demonstrates increased utilisation of the MET system and activation for patients earlier in their deterioration. The data should inform both health service planning and educational requirements for MET providers.

Introduction

The Medical Emergency Team (MET) model was first described in Sydney, Australia in the early 1990s[1] and has since been widely implemented around the world.

The concept describes a hospital-wide patient-focused system that aims to improve recognition of acute deterioration in patients and trigger a rapid response from a designated team (with critical care skills) who enact management aimed at preventing potentially avoidable adverse events (including cardiac arrest and death).[2]

The system was different from the previous standard "code" or "arrest" team model in that it aimed to assess a greater number of patients at an earlier stage of clinical deterioration[3] i.e. patients with clinical signs of impending respiratory, cardiac or neurological failure, rather than patients who had already suffered a respiratory or cardiac arrest. The model is particular suited to paediatric patients because cardiac arrest in this population is more often preceded by a more prolonged period of potentially reversible deterioration.[4]

A MET service was introduced into the Royal Children's Hospital (RCH) in Melbourne, Australia in 2002 to replace the existing "Code Blue" arrest system. Comparison of the 41 months "pre-MET" to the 48 months "post-MET"[5] showed that introduction of the system was associated with a 35% reduction in total hospital mortality and a 65% reduction in unexpected ward deaths.

The Royal Children's Hospital in Brisbane, Australia established an interdisciplinary Emergency Advisory Committee (EAC) in 1992 with medical and nursing representatives from the emergency department, paediatric intensive care unit, medical and nursing education. The committee's stated role was to "monitor, evaluate and review RCH participation in all emergency response, establish appropriate standards

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and educate all staff involved in emergency responses". The EAC sought to standardise resuscitation equipment, improve the emergency alert system, standardise trigger criteria, and ensure appropriate Basic and Advanced Life Support (BLS/ALS) training for a dedicated team involved in emergency "arrest" responses. In July 1994, RCH Brisbane replaced the "Cardiac Arrest Team" with a Medical Emergency Response Team (MERT) system. The team (MERT) comprised a doctor each from the emergency department (ED), paediatric intensive care unit (PICU) and general paediatric team, and a nurse each from the ED, PICU and Nurse Manager teams. MERT members had dedicated pagers and portable resuscitation equipment. The team was alerted via emergency buttons at patient bedsides and other clinical areas. Criteria for activation of the system remained unchanged across the 20 years the system was in place at RCH Brisbane (Fig. 1) except for the addition of "CEWT prompt" after a multi-trigger Children's Early Warning Tool[6] was introduced into the hospital in late 2011.

A draft memo from the EAC at the time stated: "*Having a low threshold for using this system, and accepting that there will be occasional false alarms, is far preferable to attempting resuscitation without appropriate staff or equipment or delaying the call for help until the patient is beyond help.*"

The RCH Brisbane MERT system (later renamed to MET) was operational 24 h a day, 7 days a week from late 1994 until the hospital changed site (and was renamed the Lady Cilento Children's Hospital) in November 2014. Data collected from all MERT/MET responses was prospectively entered into a quality assurance database from February 1995 until July 2014. Data was collected to inform system improvement and was monitored by the EAC. The MERT service was regularly revised in response to feedback and changing circumstances in the hospital environment.

The purpose of this study is to describe the patient demographics, patterns of activation and clinical outcomes of a cohort of patients triggering MET activations at a specialist paediatric hospital across a 20-year period. This study provides a description of the longest duration Medical Emergency Team data set published to date.

Methods

Source of data

This study is a single-centre observational study of prospectively collected data entered into an institutional database (registry-based study) at the Royal Children's Hospital (Children's Health Queensland) in Brisbane, Australia. The RCH Brisbane MET database contains prospectively entered data related to MET events from February 1995 to July 2014. Data related to annual patient separations (discharges) was obtained via the Hospital Based Corporate Information System (HBCIS) from the Queensland Hospital Admitted Patient Data Collection (QHAPDC).

Inclusion and exclusion criteria

A MET event was defined as any event within the facility for which the MET was activated. The MET response may have been triggered by abnormalities in patient physiology, a subjective concern on the part of the staff, or family/visitor concerns as defined by the hospital's activation policies or procedures for MET activation.

All MET events recorded in the RCH Brisbane MET database from February 1995 to July 2014 were considered initially eligible for inclusion in the study. Data included MET events involving paediatric hospital patients as well as MET events to visitors (adults and children) and staff members.

The following MET database records were excluded from analysis:

FALSE ALARMS – records identified as "false alarms" (e.g. emergency button pressed by mistake)

DUPLICATE RECORDS – where two MET events were recorded as occurring within 10 min, in the same location, to a child of the same age, without a record of multiple actual activations to the same patient, the record was considered a duplicate record.

INCOMPLETE ANNUAL DATA – where an interruption or change in data collection had resulted in >1 month of data loss from the database in any calendar year, that year of data was excluded from comparative analyses of the first and second decades of the MET system.

Data collection and analysis

Data collected for each MET activation included data related to the activation (date, time, location of event); patient demographic data (age, inpatient/outpatient/visitor); triggers for the activation; procedures and medications required during the event; and patient outcome data.

Rate of Rapid Response System activation was calculated using a computation (number of rapid response system activations per 1000 hospital separations for the time period audited) consistent with quality measures defined by the Australian Commission on Safety and Quality in Healthcare.[7]

Demographics for continuous data were presented using mean and standard deviation or median and inter-quartile range (IQR) when normality of the data was not met. Categorical data were described using frequency and percentage. The relationship between two categorical variables was assessed using a Chi-square test or Fisher's exact test when appropriate. Differences in proportions of MET events location types, MET events and reasons for MET activation at RCH Brisbane, between the first (1995–2004) and second (2005–2014) decades of the MET system were also examined using 2-sample test for equality of proportions with continuity correction. All analyses were performed using the R statistical software.[8]

Full cardiac arrest should ***not*** be the only circumstance in which a MERT response is activated.

Indications for MERT response activation include:

- Apnoea or respiratory arrest
- Airway obstruction
- Severe respiratory distress
- Prolonged seizures
- Neurological deterioration
- Shock or poor circulation requiring resuscitation
- Severe bleeding
- Total CEWT score of 8 or above or CEWT Single Observation with a score of E*
- Any other circumstance when extra medical or nursing assistance is urgently needed

MERT activation is appropriate when endotracheal intubation is performed in wards even if there appears to be adequate medical and nursing support present.

Fig. 1. MET activation criteria, RCH Brisbane 1994–2013.

Ethical approval

The retrospective data collection included only data that was routinely collected as part of a patient's admission and/or event of a MET activation. No additional patient data was collected as part of this study. Data extracted from the database for this study did not include any identifiable data fields. A separate unique study ID number was allocated to each record for this study.

The study was approved by the Children's Health Queensland Human Research Ethics Committee as a Low and Negligible Risk category project [LNR/QRCH/43011].

Results

Population characteristics

Between February 1995 and July 2014, a total of 955 MET event records were entered into the registry. After applying exclusion criteria (112 False Alarms, 9 Duplicate Records), 834 MET events were available for analysis. The method of database entry was revised in 2001 resulting in an interruption of data collection during this year. As only incomplete annual data is available for 2001 and 2014 (the year that RCH closed and was reopened as the Lady Cilento Children's Hospital), MET events from these years (n = 63) were excluded from comparative analyses of the first and second decades of the MET system, leaving 9 full years for comparison in each period.

Table 1
MET events Location Type 1995–2013 with comparison between first (1995–2004 excluding 2001) and second (2005–2013) decades of the service.

MET Event Location Type	Total: 1995–2013 (excluding 2001)	Period 1: 1995–2004 (2001 data excluded)	Period 2: 2005–2013	P-value
Inpatient Unit	530 (68.8 %)	144 (69.2%)	386 (68.6%)	0.93
Outpatient Unit	61 (7.9%)	10 (4.8%)	51 (9.1%)	0.07
Radiology	12 (1.5%)	1 (0.5%)	11 (2.0%)	0.26
Operating Suite	4 (0.5%)	0 (0%)	4 (0.7%)	0.51
PICU or HDU	23 (3.0%)	6 (2.89%)	17 (3.0%)	1
Emergency Department	46 (6.0%)	25 (12.0%)	21 (3.7%)	<.001
Public Area or External Site	93 (12.1%)	22 (10.6%)	71 (12.6%)	0.52
Not Recorded	2 (0.3%)	0 (0%)	2 (0.4%)	0.95
TOTAL	771 (100%)	208 (100%)	563 (100%)	

The majority (75%) of MET events involved paediatric inpatients (n = 620) with a further 11% occurring in children in outpatient or the emergency department, 11% in hospital visitors and 3% in hospital staff members.

The distribution of MET event location types is shown in Table 1.

Data on patient age was only available for 570 records. Patient age was only recorded in the registry from January 2000 (recorded in months of age) and date of birth was only recorded from January 2013. Prior to these dates, the dataset was minimised to improve anonymity. The median recorded age of patients was 36 months (IQR: 10.50–120). Age distribution of patients is displayed in Fig. 2. The majority (57.5%) of the MET activations for which an age was recorded involved children aged <5 years with 26% involving infants.

Temporal patterns of MET activation

MET events occurred consistently across the months of the year with no significant seasonal variation noted ($p = 0.17$). The proportion of MET events activated on weekdays was disproportionately higher (1.8 times) than that on weekend days after adjusting for the expected proportion of the week ($p < 0.001$). The proportion of MET events occurring during the day (8am to 4pm) was higher than either that during the evening (4pm to midnight) or overnight (midnight to 8am) ($p < 0.001$, 51% vs. 17.5% and 31.4%, respectively).

MET activation triggers

Documented reasons for activation of the MET response are listed in Table 2. The most frequent reasons stated for MET activation were seizure and respiratory compromise which together accounted for 49% of all MET activations in the cohort.

There was a significant increase in the frequency of MET events (MET events per 1000 hospital separations) in the second decade of the service compared to the first (3.25 vs 1.42, $p < 0.001$). The frequency of various MET activation reasons also changed significantly across the two decades of the MET system. The frequency of MET activations for cardiac arrest (per 1000 hospital separations) was significantly less in the second decade compared to the first (0.07 vs 0.16, $p = 0.02$) and that for respiratory arrest remained steady. In contrast, frequency of MET activations (per 1000 hospital separations) for cardiovascular (0.08 to 0.21, p

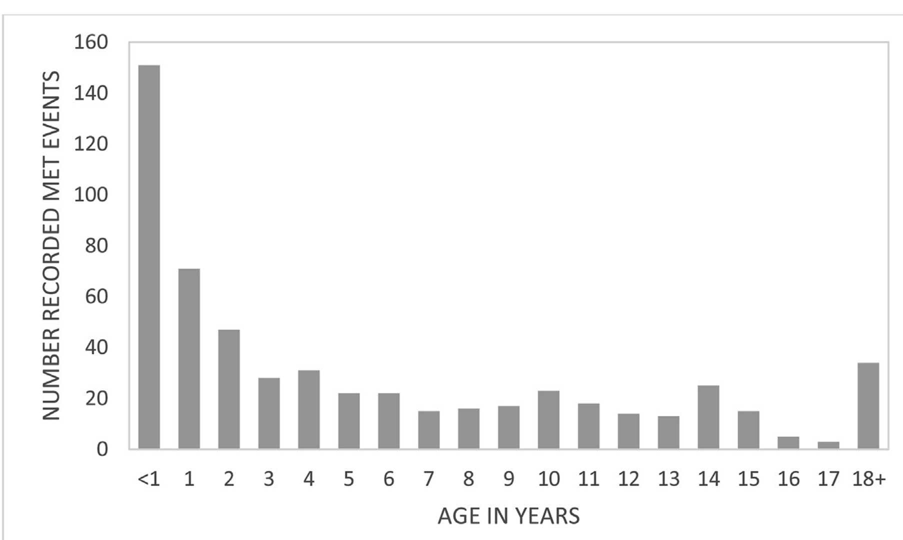

Fig. 2. Recorded age distribution of MET activation recipients (n = 570).

Table 2
Reasons for MET activation at RCH Brisbane from 1995-2013 with comparison between first (1995–2004 excluding 2001) and second (2005–2013) decades of the service.

	Total: 1995–2013 (excluding 2001)	Period 1: 1995–2004 (2001 data excluded)	Period 2: 2005–2013	p value
No. Hospital Separations (Discharges) in the period	319705	146677	173028	
Total No. MET events recorded (rate per 1000 separations)	771 (2.41)	208 (1.42)	563 (3.25)	<.001
Frequency of MET Activation Reason (rate expressed as number of MET activations per 1000 hospital separations)				
Cardiac Arrest	35 (0.11)	23 (0.16)	12 (0.07)	0.02
Cardiovascular compromise[a]	48 (0.15)	12 (0.08)	36 (0.21)	0.003
Respiratory Arrest	43 (0.13)	21 (0.14)	22 (0.13)	0.80
Respiratory Compromise[b]	189 (0.59)	62 (0.42)	127 (0.73)	<.001
Altered Level of Consciousness	96 (0.30)	12 (0.08)	84 (0.49)	<.001
Seizure	189 (0.59)	59 (0.40)	130 (0.75)	<.001
Allergic reaction/ Anaphylaxis	18 (0.06)	2 (0.01)	16 (0.09)	0.005
Haemorrhage (post-operative)	34 (0.11)	6 (0.04)	28 (0.16)	0.001
Other[c]	65 (0.20)	11 (0.07)	54 (0.37)	<.001
Not reported	54 (0.17)	0 (0)	54 (0.31)	<.001

[a] Cardiovascular Compromise: including "Arrhythmia", "Bradycardia", "Hypotension", "Shock" and "Tachycardia".
[b] Respiratory Compromise: including "Airway issue", "Apnoea", "Hypoxia/ Cyanosis", and "Respiratory Distress".
[c] Other: including "Chest Pain", "Early Warning Tool trigger", "Trauma", "Parental Concern", "Staff Concern", "Behavioural disturbance", "Hypoglycaemia", "Pain", "Labour".

$= 0.003$) or respiratory compromise (0.42 to 0.73, $p < 0.001$) significantly increased from the first to the second decade.

Resuscitative procedures

The majority of MET events did not require major resuscitative procedures (CPR, endotracheal intubation) to be performed on the patient. Bag-valve-mask (BVM) ventilation was the most common procedure performed (30% of events) followed by insertion of an intravenous cannula (22% of events), endotracheal intubation (10% of events), external chest compressions (6% of events) and insertion of an intraosseous needle (3% of events).

MET outcomes

Table 3 shows the recorded disposition of patients following a MET event. The majority of patients either remained (26.8%) in the location of the MET event - ward, ED or PICU - or were transferred to the PICU or high dependency unit (28.8%). There were only 13 deaths recorded in the cohort during a MET event (1.7% of all activations). Of these, 10 occurred during the first 9-year period and only 3 during the second 9-year period.

Discussion

This report provides a description of the clinical characteristics, procedures performed, and outcomes of the longest duration single-centre cohort of paediatric MET events published to date.

The overall clinical characteristics of our MET event cohort are consistent with the findings of the large multicentre paediatric MET cohort study involving US hospitals reporting to the American Heart Association's "Get With the Guidelines Resuscitation" (GWTG-R) registry published by Raymond et al.[9]

Table 3
Outcome of MET events at RCH Brisbane 1995–2013 with comparison between first (1995–2004 excluding 2001) and second (2005–2013) decades of the service.

Outcome of MET event	Total: 1995–2013 (excluding 2001)	Period 1: 1995–2004 (2001 data excluded)	Period 2: 2005–2013	P-value
Died	13 (1.7%)	10 (4.8%)	3 (0.5%)	<.001
Remained in Location	207 (26.8%)	35 (16.8%)	172 (30.6%)	<.001
Transferred to PICU or HDU	222 (28.8%)	52 (25.0%)	170 (30.2%)	0.19
Transferred to ED	42 (5.4%)	11 (5.3%)	31 (5.5%)	1
Transferred to Operating Suite	6 (0.8%)	0 (0%)	6 (1.1%)	0.30
Transferred to Mental Health Unit	1 (0.1%)	0 (0%)	1 (0.2%)	1
Transferred to Adult Facility	82 (10.6%)	13 (6.3%)	69 (12.3%)	0.02
Transferred to Ward	2 (0.3%)	1 (0.5%)	1 (0.2%)	1
Not recorded	196 (25.4%)	86 (41.4%)	110 (19.5%)	<.001
TOTAL	771 (100%)	208 (100%)	563 (100%)	

Our data shows an age distribution heavily skewed towards the preschool population with a median reported age matching that of the GWTG-R cohort (3 years). Our finding of a preponderance for MET activations during weekdays and daylight hours mirrored that reported by Raymond et al., although definitions of the time periods differed slightly. The decreased frequency of MET activations on weekends may be related to decreased hospital occupancy over the weekend. The reduced MET event rate overnight is harder to explain. As 25% of MET events in our cohort were triggered by seizures, the lower incidence of seizure events during sleep may be a factor in this observation.

In our cohort, respiratory distress and seizure were the most frequently recorded triggers for MET events. The GWTG-R registry data[9] reported respiratory triggers as the most common reason for MET activation but also described "staff concern" as a trigger in 23.8%. It should be noted that the GWTG-R MET registry does not include triggers of "cardiopulmonary arrest" or "acute respiratory compromise" as these are captured on separate databases.

Although the majority of MET events in our cohort did not require resuscitative interventions, the frequency of need for emergency vascular access, ventilation support, and cardiopulmonary resuscitation was supportive of these being considered core skills for any member of a paediatric medical emergency team.

Perhaps the most valuable contribution of this paper, is that the time span of data collected allows a comparison of paediatric MET systems across two decades – from the initial beginnings of MET systems around the world through to more contemporary processes. The overall frequency of MET events increased significantly across time despite no significant change in MET calling criteria across the two decades.

The increase in overall MET event frequency was reflected in a reported increase in frequency of all MET triggers except for cardiac arrest and respiratory arrests. Although the MET trigger reason was not recorded in 54 events (10%) in the second period, this could only affect our findings if a disproportionate number of these cases fell into the cardiac and/or respiratory arrest groups. Upon review of procedures performed on these events, none had received CPR and only one had received ventilatory support, making the risk of a confounding effect very minimal.

The trend of increased activation for pre-arrest events and decreased activation for arrest events is consistent with the intended aim of establishing the MET system, as previously stated: *to assess a greater number of patients at an earlier stage of clinical deterioration i.e. patients with clinical signs of impending respiratory, cardiac or neurological failure rather than patients who had already suffered a respiratory or cardiac arrest*. Several studies have reported a reduction in the frequency of cardiopulmonary arrests outside of critical care areas in both adult[10–12] and paediatric hospital settings[5,13] associated with introduction of a MET system. In contrast, the MERIT study,[14] a cluster randomised controlled trial of 23 Australian hospitals failed to show a statistically significant reduction of combined incidence of cardiac arrests, unexpected deaths and unplanned ICU admissions in those hospitals in which a MET system was introduced.

Other authors have reported an association between increased MET dose (MET events per 1000 hospital separations) and reduced hospital mortality and out of ICU arrest events in adult settings.[15–18] Our data support this association between increased MET dose and decreased cardiopulmonary arrests requiring MET intervention.

Limitations

Our study has several limitations. It reports data from a single tertiary paediatric hospital and, as such, may not be generalisable to other settings. Changes in some of the data collection elements across the 20-year time frame of the database resulted in some data elements (e.g. age) not being available for earlier events and some time periods having insufficient data to allow inclusion within our analysis (e.g. change of database entry method in 2001). The authors do not expect that the missing data for these time periods would be sufficiently different to our reported data to represent any systematic bias that would affect results. The large proportion of MET outcome (Table 3) in the "not recorded" category, limited our ability to draw any conclusions related to changes between periods for this measure.

As an observational study, we are unable to propose a causal relationship between changes in MET activation rates and the observed changes in frequency of MET event triggers. However, this study is hypothesis generating and supports the hypothesis that early identification and intervention by a MET favourably alters the clinical course of the deteriorating patient. We cannot exclude a potential confounding effect of other initiatives separate to the MET system (e.g. hospital staffing and bed distribution changes, DNR policy changes) that may have caused the effect on MET trigger patterns over time. A further exploration of the changes in MET dose and any association with in-hospital mortality rate over time may be warranted.

Conclusions

This study provides a description of the longest duration Medical Emergency Team data set published to date. The 20-year span of the data set provides not only a detailed description of the patterns of paediatric rapid response system utilisation, it also allows for analysis of trends in utilisation across this extensive time period. Across the two decades, MET events increased significantly and more METs were triggered for patients earlier in their deterioration. The maturation of the rapid response system into one of intervention at an earlier stage of patient deterioration (to lessen subsequent harm) is consistent with the initial aims of the system when initiated 25 years ago. This data should inform both health service planning and educational requirements for MET providers.

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Declaration of competing interest

None to declare.

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