ORIGINAL ARTICLE

Validity of the Manchester Triage System in paediatric emergency care

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Objective: To assess the validity of the Manchester Triage System (MTS) in paediatric emergency care, using information on vital signs, resource utilisation and hospitalisation.

Methods: Patients were eligible if they had attended the emergency department of a large inner-city hospital in The Netherlands from August 2003 to November 2004 and were <16 years of age. A representative sample of 1065 patients was drawn from 18 469 eligible patients. The originally assigned MTS urgency levels were compared with resource utilisation, hospitalisation and a predefined reference classification for true urgency, based on vital signs, resource utilisation and follow-up. Sensitivity, specificity and percentage of overtriage and undertriage of the MTS were calculated.

Results: The number of patients who used more than two resources increased with a higher level of MTS urgency. The percentage of hospital admissions increased with the increase in level of urgency, from 1% in the non-urgent patients to 54% in emergent patients. According to the reference classification, the sensitivity of the MTS to detect emergent/very urgent cases was 63%, and the specificity was 78%. Undertriage occurred in 15% of patients, of which 96% were by one urgency category lower than the reference classification. Overtriage occurred in 40%, mostly in lower MTS categories. In 36% of these cases, the MTS classified two or more urgency categories higher than the reference classification.

Conclusions: The MTS has moderate sensitivity and specificity in paediatric emergency care. Specific modifications of the MTS should be considered in paediatric emergency care to reduce overtriage, while maintaining sensitivity in the highest urgency categories.

Hospital emergency departments are increasingly visited by patients with non-urgent problems.[1–3] This leads to overcrowded waiting rooms and long waiting times. As a consequence, patients needing care urgently may not be treated in time, whereas patients with non-urgent problems may unnecessarily receive expensive emergency care. Therefore, a reliable, valid triage system is required for patient safety. Triage of paediatric patients is difficult as presenting signs and symptoms and final diagnoses differ from those of adults.[4] Several triage systems have been developed to categorise patients by urgency of care.[5–12] The Manchester Triage System (MTS), used by emergency department nurses, is a triage system that supports the determination of a patient's urgency level on the basis of discriminators embedded in problem-specific flow charts.[9 13] The triage nurse selects the most suitable flow chart for each presenting problem and uses general and specific discriminators to identify the patient's acuity. The MTS provides clarity about maximum allowed waiting time for the different levels of urgency: ''emergent'' (red) needs instantaneous evaluation, ''very urgent'' (orange) needs evaluation within 10 min, ''urgent'' (yellow) within 60 min, ''standard'' (green) within 120 min and ''non-urgent'' (blue) can wait for up to 240 min.

The MTS has predominantly been implemented throughout Europe (eg, UK, Ireland, Portugal and The Netherlands). Clearly, assigning an inappropriate low urgency level may lead to possibly dangerous delays in patient care. However, assigning an inappropriate high triage level may increase waiting time for the truly urgent cases.[14]

The MTS was developed by the Manchester Triage Group and is based on expert opinion. The scientific validity of the MTS is based on three key articles that are focused on high-risk adult patients. In a literature review, Zimmermann[15] concludes that the MTS is reliable and valid. The MTS was found to have a sensitivity of 87% for identifying chest pain of cardiac origin and was found to be a sensitive tool for identifying critically ill adult patients.[16 17] However, the validity of the MTS for standard and non-urgent problems has not been evaluated. Furthermore, no specific evaluation of the use of the MTS for paediatric patients has been carried out. As a result, only anecdotal information is available on the use of the MTS in paediatric emergency care. In particular, overtriage, assigning an inappropriate high triage level, seems to be a problem. For example, in the MTS, most children presenting with fever require medical assessment within 10 min. However, in an emergency department, many children present with fever, and assessment of these children within 10 min is neither feasible nor necessary in clinical practice.[18]

Our study aimed to assess the validity of the MTS in paediatric emergency care, using information on vital signs, resource utilisation and hospitalisation.

METHODS

Study design

This study is a retrospective observational study of the validity of the MTS in paediatric emergency care. The validity of the MTS was assessed by correlating MTS urgency categories to resource utilisation, hospitalisation and to a predefined reference classification for true urgency. The requirement for informed consent was waived by the institutional review board.

Study setting and population

Children were included from the Haga Hospital, Juliana Children's Hospital Site, a large inner-city teaching hospital with a mixed paediatric and adult emergency department in

Abbreviation: MTS, Manchester Triage System

The Hague, The Netherlands. Every year, approximately 30 000 patients attend the emergency department, of whom nearly 15 000 are children.

Study protocol and measurements

The standardised medical records of 1065 children who visited the emergency department of the Haga Hospital in the period from August 2003 until November 2004 were reviewed. Selection of the records was based on the originally assigned MTS urgency category. All retrievable records of patients assigned to emergent or non-urgent categories were selected, and a random sample was drawn from the other three categories: very urgent, urgent and standard. The random sample (an approximate percentage of the original group size) was taken from each of the three categories, using SPSS V.12.0.1. Patients whose urgency category according to the MTS was manually overruled by emergency department nurses were excluded (2.4%).

To assess the validity of the MTS, a reference classification for true urgency is necessary. Firstly, we assess the correlation between MTS-assigned urgency category and resource utilisation or hospitalisation as an overall indicator for urgency.[5 7 19] Resource utilisation was defined, according to others, as undergoing simple laboratory, extensive laboratory or radiology tests (radiography, ultrasound, computed tomography/magnetic resonance imaging) or receiving drugs or an intervention at the emergency department (see appendix A for detailed definitions).[5]

Subsequently, in an expert meeting, a reference classification as proxy for true urgency was defined. The reference classification was based on a combination of objective information on vital signs, presence of a possible life-threatening condition, resource utilisation (diagnostic investigation and treatment) and follow-up (hospitalisation, ambulatory care or discharge). For each patient, these data were collected from the standardised emergency department form, medical record and the computer-based hospital information system (see appendix A for collected data). Data were collected by trained medical students using standardised data collection forms, and was blinded for originally assigned MTS urgency category. All patients were assigned an urgency category according to the predefined reference classification based on consensus between paediatricians and paediatric surgeons. The classification is hierarchical—that is, when vital signs are outside the Pediatric Risk of Mortality III—normal range, the patient is assigned to the emergent category; when vital signs are normal, the presence of a possible life-threatening condition discriminates very urgent patients; if a possible life-threatening condition is absent, the extent of diagnostic tests, treatment and follow-up discriminates between urgent and standard patients; finally, non-urgent patients were defined as patients who did not undergo diagnostic tests, did not receive treatment (at the emergency department) and who were discharged without follow-up. A classification matrix and detailed definitions of all reference classifications are shown in appendix B.

Data analysis

Firstly, we compared MTS level of urgency with resource utilisation or hospitalisation. Next, the MTS urgency classification was compared with the reference classification. The validity of the MTS is expressed as percentage agreement between the reference classification and the MTS. Undertriage is defined as an MTS classification at least one urgency level lower than the reference classification. Overtriage is defined as an MTS classification of at least one urgency level higher than the reference classification. SPSS V.12.0.1 was used for statistical analyses with weighting by the inverse of the sampling ratio.

RESULTS

A total of 18 469 patients, 0–16 years old, visited the emergency department during the study period from August 2003 to November 2004. A total of 1065 patients were included in this study. When stratified by urgency category, no significant differences were found in the distribution of gender, age, specialty and referral profile between the original dataset and the study sample (table 1).

Table 2 gives an overview of resource utilisation stratified by level of urgency according to the MTS. The number of patients who used more than two resources increased with a higher level of (MTS) urgency. In the lowest urgency category, more patients used no resources (68%) than in the highest urgency category (13%). In the non-urgent category 28% of the patients used one resource, and in the standard category 42% used at least one resource.

Table 3 shows the follow-up after the emergency department visit. Hospitalisation is correlated with MTS urgency: the percentage of hospital admissions increased with higher level of urgency, from 1% in the non-urgent patients to 54% in emergent patients.

In 65 patients the reference classification could not be determined, as essential information was missing. Hence, a comparison between reference and MTS classification could be made in 1000 patients (94%). Table 4 shows the agreement between the MTS classification and the reference classification. The 1000 cases were weighted with the inverse of the sampling ratio. In 45% of all cases, patients had exactly the same priority in the MTS and reference classifications (0.7+1.6+11.5+31.0+0.2%). In 40% of all cases the assigned MTS urgency category was higher than the reference classification (ie, overtriage). In 15% of all cases the MTS urgency category was lower than the reference classification (ie, undertriage). In 96% of these cases, the MTS urgency category was one urgency category lower than the reference classification.

The sensitivity of the MTS to detect emergent/very urgent patients was 63% (calculated as (0.7+1.3+0.1+1.6)/(2.0+3.9)) and the specificity was 78%.

Table 1 Baseline characteristics

	Original (n = 18 469)	Sample (n = 1065)
Male sex, n (%)	10 575 (57.3)	588 (55.2)
Age (years), mean (SD)	4.9 (4.3)	4.6 (4.3)
Specialty		
Paediatrics	10 648 (57.7)	725 (68.1)
Paediatric surgery	6792 (36.8)	303 (28.5)
Other*	1029 (5.5)	37 (3.5)
Referral, n (%)		
Self-referred	11 216 (60.7)	588 (55.2)
General practitioner	3985 (21.6)	230 (21.6)
Paediatrician/paediatric surgeon	1886 (10.2)	90 (8.4)
Ambulance	977 (5.3)	60 (5.6)
Other/unknown†	405 (2.2)	97 (9.1)
MTS category, n (%)		
Emergent	152 (0.8)	127
Very urgent	3638(19.7)	276
Urgent	4414 (23.9)	271
Standard	7535 (40.8)	284
Non-urgent	148 (0.8)	107
Missing	2142 (11.6)	NA
Over-ruled	440 (2.4)	NA

MTS, Manchester Triage System; NA, not applicable.
*Paediatric subspecialties—for example, neurology, gastroenterology.
†Other hospitals, departments other than paediatrics or paediatric surgery, unknown.

Table 2 Resource utilisation according to MTS urgency category

MTS classification	No of resources used (%)			
	None	1	2	>2
Emergent (n = 127)	12.6	45.7	29.1	12.6
Very urgent (n = 276)	29.3	45.3	20.3	5.1
Urgent (n = 271)	26.9	42.8	28.4	1.8
Standard (n = 284)	41.5	41.9	16.2	0.4
Non-urgent (n = 107)	68.2	28.0	3.7	0.0

MTS, Manchester Triage System.

Table 3 Hospitalisation according to MTS urgency category

MTS classification (n)	Hospitalisation (%)
Emergent (127)	53.5
Very urgent (276)	28.6
Urgent (271)	16.2
Standard (284)	6.0
Non-urgent (107)	0.9

MTS, Manchester Triage System.

DISCUSSION

Our study aimed to assess the validity of the MTS in paediatric emergency care. A high level of urgency according to the MTS was correlated with the utilisation of two or more resources and with a high percentage of hospitalisation. However, in the lower urgency categories, 28% of the non-urgent and 42% of the standard patients used at least one resource. Hospitalisation was correlated with MTS urgency. Using a predefined reference classification including refined indicators for true urgency, we found that the MTS was neither very sensitive nor very specific in a paediatric population.

In 15% of all cases, the urgency category as assigned by the MTS was lower than the reference classification. We found a sensitivity of 63% and a specificity of 78% for detecting emergent/very urgent cases. Yet, as emergent cases according to the reference classification were always classified as emergent or very urgent in the MTS, the system seems to be reasonably safe in a paediatric population. In only 0.6% of all cases was the MTS urgency category two categories lower than the reference classification. According to the reference classification, 14% of the very urgent patients (ie, having a potential life-threatening condition) were classified as standard by the MTS. This applied mainly to children who had an apparently life-threatening event. Although most of these children do not present as having an urgent condition, the patient history requires the attending physician to exclude a serious illness as the cause of the apparently life-threatening event.[20]

Overtriage by the MTS seemed to be a problem in the paediatric population. Among the paediatric patients, 40% were assigned an urgency category in the MTS that was too high according to the reference classification. A difference of at least two urgency categories between the MTS and the reference classification was found in 14% of all patients. These were, for example, patients who presented with fever, required no diagnostic investigation, received the advice to use antipyretic drugs and were followed up by telephone. In the MTS these patients were classified as very urgent, whereas in the reference classification they were rated as standard.

In the adult population, MTS performance was assessed only for urgent cases or specific conditions. MTS was found to have a sensitivity of 87% for identifying chest pain of cardiac origin.[17] Further, it was concluded that the MTS is a sensitive tool for identifying critically ill patients.[16] Overtriage has not been studied, although mixing non-urgent conditions with urgent conditions can result in delayed care for truly urgent cases. The validity of the MTS in a paediatric population has not been discussed in the current literature. A paediatric Canadian Triage and Acuity Scale was developed and paediatric adjustments were made in the Emergency Severity Index (V.4).[8 12 21] These examples underline that triage of the paediatric patient differs from adult triage. Further, the reliability of triage systems, measured as inter-rater agreement, rather than validity is mostly assessed.[5 10 22–25]

It is difficult to evaluate the validity of a triage system. Resource utilisation or hospitalisation has been shown to be correlated with level of urgency in paediatric patients, and has previously been used to validate the Emergency Severity Index.[5 7 19] In our study, resource utilisation was only moderately correlated with level of urgency when two resources were used, or when no resources were used. No correlation was found in the patients who used one or two resources. Hospitalisation was correlated with MTS level of urgency, but seemed to be a crude, dichotomous measure for true urgency. The reference classification used in this study was therefore based on a combination of objective data on vital signs, presence of a possible life-threatening condition, resource utilisation (diagnostic tests and treatment) and follow-up (hospitalisation, ambulatory care and discharge).

In the MTS, however, the decision made at triage is based on a rapid assessment rather than a diagnosis, as the urgency of a condition must be assessed at presentation.[9] The MTS is advocated to be a dynamic system; therefore, it could be an advantage that, in the reference classification, improvement and worsening of the clinical condition are taken into account. However, it is a disadvantage that these tests and decisions do not necessarily reflect the child's condition at presentation. Windle and Mackway-Jones argue that, in the absence of a gold standard for assessing urgency at presentation, it is not possible to prove that any triage system works.[26] From a decision-analytical point of view, urgency should be defined by the degree of deterioration in outcome that is caused by delay in seeing a doctor and the delay in initiating diagnostic investigation and treatment. A truly emergent situation has a steep slope of deterioration regarding the patient's outcome with every minute of delay. This slope is much less steep for truly less urgent conditions. So, urgency requires judgement of the natural course of a condition, which is hard to obtain empirically. Therefore, to date most studies used either expert panels or resource utilisation as proxies for true urgency.[5 19 25 27 28]

In our sample, exploration of the effects of a modification of the MTS based on patient's age did not improve its performance. Flow chart-specific modifications seem to be necessary to improve the MTS for paediatric emergency care.

This study has some limitations. Firstly, we attempted to include all patients originally assigned to the emergent and non-urgent MTS categories. However, not all medical records of these patients were retrievable (25 emergent cases and 41 non-urgent cases). Secondly, the reference classification was conservative, especially regarding the definition of emergent cases. All patients with a vital sign outside the normal range according to the Pediatric Risk of Mortality III were classified as emergent.[29] This may have resulted in a relatively high number of patients classified as emergent according to the reference classification, and subsequently in a low sensitivity of the MTS. Thirdly, local variation in case-mix and medical practice regarding diagnostic and therapeutic interventions might have influenced the results.

Table 4 Comparison between the MTS and reference classification, based on 1000 cases

	Reference classification	Total (%)				
MTS classification	Emergent	Very urgent	Urgent	Standard	Non-urgent	
Emergent	0.7	*0.1*	*0.1*	*0.1*	*0*	1.0
Very urgent	**1.3**	1.6	*8.0*	*11.8*	*0.9*	23.6
Urgent	**0**	**1.6**	11.5	*13.5*	*1.2*	27.8
Standard	**0**	**0.5**	**11.1**	31.0	*4.1*	46.7
Non-urgent	**0**	**0**	**0**	**0.6**	0.2	0.9
Total*	2.0	3.9	30.7	57.0	6.4	100

MTS, Manchester Triage System.
*Differences in column and row totals might have occurred due to rounding off.
Values in italics represent undertriage.
Values in bold represent overtriage.

In conclusion, the MTS has moderate sensitivity and specificity in paediatric emergency care. A substantial proportion of seriously ill patients will be recognised, but overtriage is a problem. Specific modifications of the MTS in paediatric emergency care should be considered to reduce overtriage, while maintaining sensitivity in the highest urgency categories.

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APPENDIX A REFERENCE CLASSIFICATION PARAMETERS

VITAL SIGNS: NORMAL VALUES ACCORDING TO PEDIATRIC RISK OF MORTALITY III (PRISM III)[29]

Table AI gives the reference classification parameters corresponding to the following conditions: heart rhythm: arrhythmia; respiration pattern: inspiratory stridor, respiratory insufficiency; temperature: $\leqslant 33℃$ or $>41℃$; oxygen saturation: absolute percentage, cut-off $<90\%$; level of consciousness: decreased, convulsive at arrival, coma.

PRESENCE OF A POSSIBLE LIFE-THREATENING CONDITION

Meningitis, sepsis, high-energy trauma, substantial external blood loss or trauma (sharp/blunt) leading to substantial blood loss, aorta dissection, $\geqslant 10\%$ dehydration, (near-) drowning, electric trauma, apparently life-threatening event, possible dangerous intoxication, $\geqslant 10\%$ burns, facial burns or possible inhalation trauma, other (specified).

DIAGNOSTIC INVESTIGATION

- Simple laboratory tests (complete blood count, electrolytes, liver enzymes, renal function, urine/stool cultures, nasal swabs)[i].

Table A Reference classification parameters

Age	Respiratory rate/min	Systolic BP (mm Hg)	Heart rate/min
<1 month	15–90	55–160	80–215
1–12 months	10–70	65–160	60–215
1–12 years	10–70	75–200	45–185
>12 years	10–70	85–200	40–145

BP, blood pressure.

- Imaging (radiograph, ultrasound imaging)[ii].
- Extensive laboratory tests (blood culture, CSF puncture) or computed tomography/magnetic resonance imaging[ii].

TREATMENT

- Rx: simple advice or medication on prescription
- Rx at the emergency department: oral medication at the emergency department (ie, ORS, prednisone, antibiotics) or small surgical intervention (suture, debridement, bandage)[ii].
- Intervention: intravenous drugs or intervention at the emergency department (including fluids, aerosols) or surgical intervention (including casting, gastrogavage, inguinal hernia reposition, luxation reposition)[ii].
- Other (specified)[ii].

FOLLOW-UP

- General practitioner/telephone contact
- Outpatient/emergency department
- Hospital admission

[i]One or more items were counted as one resource.[5]
[ii]Each item was counted as one resource.

APPENDIX B REFERENCE CLASSIFICATION MATRIX AND DEFINITIONS OF REFERENCE URGENCY CATEGORIES

Table BI gives the reference classification matrix.

Emergent: Vital parameters: abnormal

Very urgent: Possible life-threatening condition: present

Urgent: One of the following combinations:

- Intervention at the emergency department, diagnostic investigation and follow-up not applicable.
- Extended laboratory diagnostics and *x* ray/ultrasound imaging, intervention.
- Extended laboratory diagnostics or *x* ray/ultrasound imaging and oral drugs or small surgical intervention at the emergency department. Extended laboratory diagnostics or *x* ray/ultrasound imaging and drugs on prescription, and outpatient/emergency department follow-up within 48 h.
- Hospital admission and some diagnostic investigation, Rx at emergency department or intervention.

Standard: All patients who were not classified as urgent or non-urgent.

Non-urgent: Diagnostic investigation: none. Treatment: none/drugs on prescription. Follow-up: none.

Table B Reference classification matrix

			Diagnostics			Therapy			Follow-up		
	Vital	PLC	Simple	Imaging	Extensive	Rx	Rx at ED	Intervention	Tel./GP	Outpatient	Hospitalisation
Emergent	**1**	NA	NA			NA			NA		
Very urgent	0	**1**		NA			NA			NA	
Urgent	0	0		NA		0	0	**1**		NA	
	0	0		NA		0	**1**	0	NA	0	**1**
	0	0	**1**	0	0		NA		NA	0	**1**
	0	0	0	**1**	0		NA		NA	0	**1**
	0	0	0	0	**1**		NA		NA	0	**1**
	0	0	0	**1**	0	**1**	0	0	NA	**1**	0
	0	0	0	0	**1**	**1**	0	0	NA	**1**	0
	0	0	0	**1**	0	0	**1**	0		NA	
	0	0	0	0	**1**	0	**1**	0		NA	
	0	0	0/**1**	**1**	**1**		NA			NA	
Standard	All other combinations										
Non-urgent	0	0	0	0	0	0/**1**	0	0	0	0	0

1, present; 0, absent; ED, emergency department; GP, general practitioner; NA, not applicable; PLC, possible life-threatening condition; Rx, medication on prescription.