What's Known on This Subject: Children with chronic illnesses tend to be sicker during infections than previously healthy children but are triaged in the same way, even though the validity of triage systems has not yet been evaluated in these chronically sick children.

What This Study Adds: The performance of the Manchester Triage System was lower for children with a chronic illness than for previously healthy children. Children with cardiovascular illnesses, respiratory illnesses, gastrointestinal illnesses, or other congenital or genetic defects were especially at risk of being undertriaged.

Abstract

Objective: This prospective observational study aimed to assess the validity of the Manchester Triage System (MTS) for children with chronic illnesses who presented to the emergency department (ED) with infectious symptoms.

Methods: Children (<16 years old) presenting to the ED of a university hospital between 2008 and 2011 with dyspnea, diarrhea/vomiting, or fever were included. Chronic illness was classified on the basis of International Classification of Diseases, Ninth Revision, Clinical Modification, codes. The validity of the MTS was assessed by comparing the urgency categories of the MTS with an independent reference standard on the basis of abnormal vital signs, life-threatening working diagnosis, resource utilization, and follow-up. Overtriage, undertriage, and correct triage were calculated for children with and without a chronic illness. The performance was assessed by sensitivity, specificity, and diagnostic odds ratios, which were calculated by dichotomizing the MTS into high and low urgency.

Results: Of the 8592 children who presented to the ED with infectious symptoms, 2960 (35%) had a chronic illness. Undertriage occurred in 16% of children with chronic illnesses and in 11% of children without chronic illnesses (P < .001). Sensitivity of the MTS for children with chronic illnesses was 58% (95% confidence interval [CI]: 53%–62%) and was 74% (95% CI: 70%–78%) for children without chronic illnesses. There was no difference in specificity between the 2 groups. The diagnostic odds ratios for children with and without chronic illnesses were 4.8 (95% CI: 3.9–5.9) and 8.7 (95% CI: 7.1–11), respectively.

Conclusions: In children presenting with infectious symptoms, the performance of the MTS was lower for children with chronic illnesses than for children without chronic illnesses. Nurses should be particularly aware of undertriage in children with chronic illnesses. Pediatrics 2013;132:e1602–e1608

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Key Words: child, triage, emergency medical services, validity, chronic disease

Abbreviations: CI—confidence interval; DOR—diagnostic odds ratio; ED—emergency department; IV—intravenous; MTS—Manchester Triage System

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New insights in biomedical science for children have improved treatments for previously untreatable conditions and increased survival. Although these improved treatments have led to a decline in mortality, there has been a simultaneous increase in children with chronic illnesses who tend to be sicker during acute infectious diseases than those who were previously healthy.

At the emergency department (ED), triage systems aim to recognize patients who need immediate care to prevent deterioration while patients are waiting. The Manchester Triage System (MTS), commonly used in Europe, was developed for both adults and pediatric emergency care. The MTS consists of 52 flowcharts that together represent the range of patients presenting symptoms at the ED. All flowcharts contain additional signs and symptoms (discriminators), the presence of which defines the patient’s urgency category. The 5 urgency categories correspond to the maximum waiting times before being seen by a physician. The urgency categories of the MTS are as follows: (1) immediate, immediate evaluation; (2) very urgent, evaluation within 10 min; (3) urgent, evaluation within 60 min; (4) standard, evaluation within 120 min; and (5) non-urgent, evaluation within 240 min.

Although some MTS flowcharts include the discriminator “significant medical history,” defined as “any preexisting medical condition requiring continual medication or other care,” children with chronic illnesses are triaged in the same manner as previously healthy children. However, the validity of the MTS for children with chronic illnesses has not yet been evaluated. Therefore, the aim of the current study was to assess the performance of the MTS for children with chronic illnesses who presented to the ED with infectious symptoms. The performance of the MTS for children with chronic illnesses was compared with that of the MTS in previously healthy children by using an independent reference standard as the outcome measure.

**METHODS**

**Study Design**

We conducted a prospective observational study on the validity of the MTS in children with chronic illnesses defined according to a list of diagnostic codes for congenital and chronic acquired disorders.

**Settings and Selection of Participants**

Included were all children aged ≤16 years who presented at the ED of Sophia Children’s Hospital (Rotterdam, The Netherlands) between January 2008 and January 2012. This pediatric ED is part of the Erasmus University Medical Center, is open 24 hours a day, and receives ~9000 children annually. All children were triaged with the Dutch translation of the first (January 2008 through July 2009) or second (August 2009 through December 2011) edition of the MTS. Both versions of the MTS contained the same validated adjustments for triage of febrile children. Eligible children were those who presented at the ED with diarrhea and/or vomiting, shortness of breath, or fever.

**Ethical Approval**

This study is part of an ongoing study on validation of the MTS. The Medical Ethics Committee of the Erasmus MC approved the study, and the requirement for informed consent was waived.

**Definitions**

Diarrhea and/or vomiting and shortness of breath were defined according to whether children were allocated to the MTS flowcharts “diarrhea and vomiting” or “shortness of breath in children,” respectively. Fever was defined as follows: fever as reason for attendance, fever selected as triage discriminator, or a body temperature of ≥38.5°C rectally measured at the ED according to our previous studies.

Chronic illnesses are coded according to a widely used list of diagnostic codes for congenital and chronic acquired disorders. This list was based on the International Classification of Diseases, Ninth Revision, Clinical Modification, codes that represent chronic illnesses that can be “reasonably expected to last at least 12 months (unless death intervenes) and to involve either several different organ systems or 1 organ system severely enough to require specialty pediatric care and probably some period of hospitalization in a tertiary care center.”

In summary, the list distinguishes the following: (1) neuromuscular illnesses, divided into brain and spinal cord malformations, mental retardation, central nervous system degeneration and diseases, infantile cerebral palsy, and muscular dystrophies and myopathies; (2) cardiovascular illnesses, divided into heart and great vessel malformations, cardiomyopathies, conduction disorders, and dysrhythmias; (3) respiratory illnesses, divided into respiratory malformations, chronic respiratory diseases, and cystic fibrosis; (4) renal illnesses, divided into congenital anomalies and chronic renal failure; (5) gastrointestinal illnesses, divided into congenital anomalies, chronic liver diseases and cirrhosis, and inflammatory bowel diseases; (6) hematologic or immunologic illnesses, divided into sickle cell disease, hereditary anemias, hereditary immunodeficiencies, and acquired immunodeficiencies; (7) metabolic illnesses, divided into amino acid metabolic disorders, carbohydrate metabolic disorders, lipid metabolic disorder, storage disorders, and other metabolic disorders; (8) other...
congenital or genetic defects divided into chromosomal anomalies, bone and joint anomalies, diaphragm and abdominal wall anomalies, and other congenital anomalies; and (9) malignancy or malignant neoplasms. Patients were only categorized into this last category if they received treatment at the time of presentation to the ED.

**Outcome Measures**

An independent reference standard with 5 urgency categories was used as proxy for true urgency. Details of the reference standard and the actual reference matrix have been published earlier. The 5 urgency categories were as follows:

1. immediate (patients who had abnormal vital signs according to the Pediatric Risk of Mortality Score III);
2. very urgent (patients who were diagnosed with life-threatening conditions defined as meningitis, sepsis, high energetic trauma, substantial blood loss, aorta dissection, >10% dehydration, (near) drowning, electric trauma, possible dangerous intoxication, >10% burns, and facial burns or possible inhalation trauma);
3. urgent (patients who received intravenous [IV] medication [including aerosols and fluids] or casting or inguinal hernia reposition or ligation at the ED; patients who had some diagnostic workup or received oral medication or small surgical interventions, eg, bandage at the ED, and were admitted to hospital; patients who had extended laboratory diagnostics including blood culture, cerebrospinal fluid puncture or multiple laboratory tests, or imaging and who received therapy at the ED or small surgical interventions; patients who had imaging and extended laboratory diagnostics; patients who had extended laboratory diagnostics or imaging at the ED, received some therapy [including medication on prescription or simple advice] at the ED, and had a planned follow-up visit within 24 h);
4. standard (patients who had some diagnostic workup or therapy at the ED or were admitted to hospital or had a planned follow-up visit without meeting the criteria for urgent; and
5. nonurgent (patients with no diagnostic workup, no treatment at the ED, and who were discharged without a planned follow-up visit).

**Statistical Analysis**

First, we compared the performance of the first edition of the MTS with the performance of the second edition of the MTS to investigate whether the 2 data sets of children presenting with infectious symptoms could be combined.

Second, we compared the MTS urgency categories with the categories of the independent reference standard to calculate percentages of overtriage, correct triage, and undertriage. These percentages of children with a chronic illness were compared with those of children without a chronic illness by using a \( \chi^2 \) test. A \( P \) value \( \leq .05 \) was considered statistically significant.

In addition, we compared sensitivity, specificity, and the diagnostic odds ratio (DOR). The DOR (with a range from zero to infinity) is a measure that combines sensitivity and specificity (DOR = [sensitivity/1-sensitivity]/[1-specificity/specificity]) and represents the ratio of the odds of positivity in diseased patients relative to the odds of positivity in nondiseased patients. To calculate sensitivity, specificity, and the DOR, patients were categorized as high urgent (“immediate” or “very urgent”) and low urgent (“urgent,” “standard,” and “nonurgent”). The differences between the DORs of children with and without a chronic illness were tested by using interaction terms in logistic regression. A \( P \) value \( \leq .05 \) was considered statistically significant.

Finally, we performed a subgroup analysis for the 9 categories of chronic illnesses, infectious condition, and age (divided into 5 categories: 0–3 months, 3–12 months, 1–4 years, 4–8 years, and >8 years). To correct for multiple testing, for differences in DORs a \( P \) value \( \leq .01 \) was considered statistically significant.

Analyses were performed with the IBM SPSS software, version 20 (IBM SPSS Statistics, IBM Corporation, Armonk, NY).

**RESULTS**

A total of 26 312 children had visited the ED, 7208 (27.4%) of whom had a chronic illness. Infectious symptoms were present in 8592 (33%) of all children, including 2960 (35%) with a chronic illness. Of this latter group, 531 (18%) patients had a neuromuscular illness, 326 (11%) had a cardiovascular illness, 262 (9%) had a respiratory illness, 266 (9%) had a renal illness, 390 (13%) had a gastrointestinal illness, 131 (4%) had a hematologic or immunologic illness, 247 (8%) had a metabolic illness, 467 (16%) had a congenital or genetic defect, and 340 (12%) children had a malignancy.

The overall performance of the first edition of the MTS (January 2008 through July 2009) was slightly better than that of the second edition of the MTS (August 2009 through December 2011) for children presenting with infectious symptoms (\( P = .02 \)). However, because this finding showed no interaction with the presence of a chronic illness (\( P = .73 \)), we combined the 2 data sets for the analysis of children with and without a chronic illness.
Children With and Without a Chronic Illness

Children with a chronic illness were more often male and were older than children without a chronic illness ($P = .04$ and $< .001$, respectively). Moreover, children with chronic illnesses received more extensive diagnostics, more IV therapy, and were more often hospitalized than children without a chronic illness (all $P \leq .001$) (Table 1).

Validity

The MTS urgency was not available for 1% ($n = 25$) of the children, and the reference standard could not be provided for 93 children. Therefore, 8574 children with infectious symptoms remained for analysis of the validity of the MTS.

![Table 1](https://example.com/tables/characteristics_of_the_study_population)

The performance of the MTS in children with a chronic illness differed from that in children without a chronic illness. In patients with a chronic illness, the Manchester Triage category agreed with the reference standard in 35% of patients, compared with in 30% of the children without a chronic illness. Undertriage was more common in children with a chronic illness than in those without chronic illness (17% vs 11%), whereas overtriage was more frequent in children without a chronic illness than in those with a chronic illness (59% vs 48%). Figure 1 presents the percentages for overtriage, correct triage, and undertriage per chronic illness subgroup.

The sensitivity of the MTS for children with a chronic illness (59% vs 48%). Figure 1 presents the percentages for overtriage, correct triage, and undertriage per chronic illness subgroup.

The performance of the MTS in children with a chronic illness was 74% (95% confidence interval [CI]: 70%–78%) and was 58% (95% CI: 53%–62%) for children with chronic illness. There was no significant difference in specificity between the 2 groups: the specificity was 75% (95% CI: 74%–77%) for children without chronic illness and 78% (95% CI: 76%–79%) for children with chronic illness. The DOR of the MTS in children without chronic illness was 8.7 (95% CI: 7.1–11), which was higher ($P < .001$) than the DOR of the MTS in children with a chronic illness, ie, 4.8 (95% CI: 3.9–5.9).

Subgroup analyses revealed that the performance of the MTS was significantly lower in children with a cardiovascular illness, a respiratory illness, a gastrointestinal illness, or another congenital or genetic defect, compared with children without a chronic illness (Table 2). In addition, of all children who presented at the ED with fever without dyspnea or vomiting/diarrhea, children with a chronic illness were less often correctly classified than those without a chronic illness.

**DISCUSSION**

The overall performance of the MTS in patients with infectious symptoms was lower among children with a chronic illness than in those without a chronic illness. Moreover, children with a chronic illness were at higher risk of being undertriaged when the MTS categories were compared with an independent reference standard. Our subgroup analyses revealed that, compared with the performance of the MTS in children without a chronic illness, the performance of the MTS was significantly lower in children with a cardiovascular illness, a respiratory illness, a gastrointestinal illness, or another congenital or genetic defect. In addition, all children who presented to the ED with fever without dyspnea or vomiting/diarrhea, children with a chronic illness were less often correctly classified than those without a chronic illness.
Despite the identification of certain patient subgroups in which the MTS validity was low, it was not feasible to propose specific modifications for children with a chronic illness from our database: the heterogeneity in these subgroups was too large to identify urgency by a few discriminators. Therefore, more studies are needed to identify specific features of these undertriaged children with chronic illness. Currently, we can only recommend that nurses take into account an individual patient’s chronic illness when triaging and, if necessary, use their experience to overrule the MTS.

The validity of the MTS depends on the accuracy of the nurse who applies the system (interrater agreement). A previous study in our hospital revealed that the interrater agreement of the MTS (expressed by a weighted $\kappa$) was 0.83 (95% CI: 0.74–0.91) for written case scenarios and 0.65 (95% CI: 0.56–0.72) for simultaneous triage of actual patients.\textsuperscript{14} Although we did not include chronic illnesses in the written case scenarios, children with chronic illnesses were included during simultaneous triage. The interrater agreement was the same for children with and without chronic illness (data not shown).

Second, in the current study, children with a chronic illness had increased resource utilization and were more frequently hospitalized than children without a chronic illness. These results are in line with other studies on hospitalization and utilization in children with chronic illnesses.\textsuperscript{15–17} This finding can partly be explained by the difference in decision-making around admission and resource utilization between children with and without a chronic illness. For example, children with a chronic illness might more frequently be hospitalized because of challenges in clinical assessment that require longer observation.\textsuperscript{16} On the other hand, children with chronic illness may have advanced medical care at home and therefore stay at home, whereas previously healthy children are hospitalized.

However, despite these different strategies for hospitalization and resource use, we believe that this did not affect the final urgency level as assessed by the reference standard. The reference standard only classifies hospitalized children as urgent if the reason for hospitalization was medical, e.g., abnormal vital signs, requirement of IV medication or fluids, failure to ingest medication (e.g., need for a nasogastric tube), or a surgical intervention. For this reason, the decision to identify patients as urgent was made on the basis of the patient’s

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FIGURE 1
Percentages for overtriage, correct triage, and undertriage per chronic illness subgroup.
<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Number of patients (N = 8374)</th>
<th>High Urgency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MTS Reference Standard</td>
<td>Undertriage, %</td>
</tr>
<tr>
<td>Chronic illness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No chronic illness</td>
<td>5302</td>
<td>29.3</td>
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<tr>
<td>Neuromuscular</td>
<td>516</td>
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<tr>
<td>Cardiovascular</td>
<td>317</td>
<td>34.6</td>
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<tr>
<td>Respiratory</td>
<td>258</td>
<td>39.8</td>
</tr>
<tr>
<td>Renal</td>
<td>258</td>
<td>16.4</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>379</td>
<td>17.0</td>
</tr>
<tr>
<td>Hematologic or immunologic</td>
<td>122</td>
<td>20.2</td>
</tr>
<tr>
<td>Metabolic</td>
<td>241</td>
<td>21.8</td>
</tr>
<tr>
<td>Other congenital or genetic defect</td>
<td>457</td>
<td>31.5</td>
</tr>
<tr>
<td>Malignancy</td>
<td>324</td>
<td>19.9</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;3 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No chronic illness</td>
<td>506</td>
<td>41.1</td>
</tr>
<tr>
<td>Chronic illness</td>
<td>121</td>
<td>35.5</td>
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<tr>
<td>3 months–1 year</td>
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<td></td>
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<tr>
<td>No chronic illness</td>
<td>1270</td>
<td>24.4</td>
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<tr>
<td>Chronic illness</td>
<td>540</td>
<td>28.8</td>
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<tr>
<td>1–4 years</td>
<td></td>
<td></td>
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<tr>
<td>No chronic illness</td>
<td>2234</td>
<td>32.7</td>
</tr>
<tr>
<td>Chronic illness</td>
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<td>27.1</td>
</tr>
<tr>
<td>4–8 years</td>
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<td></td>
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<tr>
<td>No chronic illness</td>
<td>857</td>
<td>22.7</td>
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<tr>
<td>Chronic illness</td>
<td>651</td>
<td>27.7</td>
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<tr>
<td>8–16 years</td>
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<tr>
<td>No chronic illness</td>
<td>635</td>
<td>24.9</td>
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<tr>
<td>Chronic illness</td>
<td>529</td>
<td>28.3</td>
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<td>Presenting symptom</td>
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<tr>
<td>Shortness of breath</td>
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<tr>
<td>No chronic illness</td>
<td>1464</td>
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<tr>
<td>Chronic illness</td>
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<tr>
<td>Diarrhea/vomiting</td>
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<tr>
<td>No chronic illness</td>
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<td>13.3</td>
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<tr>
<td>Chronic illness</td>
<td>717</td>
<td>14.3</td>
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<tr>
<td>Fever</td>
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<tr>
<td>No chronic illness</td>
<td>2900</td>
<td>25.0</td>
</tr>
<tr>
<td>Chronic illness</td>
<td>1371</td>
<td>18.7</td>
</tr>
</tbody>
</table>

*P* values < .01 were considered significant. Ref, reference.

*P* values for comparison between the subgroup DOR and the DOR of the reference group.
clinical condition without taking into account nonmedical factors. Therefore, conclusions concerning the validity of the MTS in children with and without a chronic illness are likely to be unbiased.

To our knowledge, this is the first study to examine the validity of the MTS in children with a chronic illness. The study included a good case mix of nearly 9000 children, selected from a multicultural, inner-city, university ED population. Because our percentages of children with chronic illnesses are comparable to the 20% to 35% reported in earlier studies on chronic illness, we believe that our results are probably generalizable to other Western tertiary pediatric EDs.

It should be noted that our results might have been biased by the way in which chronic illness was defined. In the current study, children were classified into chronic illness subcategories according to the International Classification of Diseases, Ninth Revision, Clinical Modification, codes. This method implies that children should have previously visited the hospital to be classified as having a chronic illness; therefore, children with a chronic illness might be incorrectly classified as a child without chronic illness. The difference between the validity of the MTS in children with and without a chronic illness can therefore be underestimated.

In addition, the way in which chronic illnesses were defined might influence why we were unable to improve the MTS for children with chronic illness in whom the validity was low. We created subgroups on the basis of diagnostic groups, whereas a recent study on chronic illnesses created subgroups on the basis of patients’ complexity. Classification based on patients’ complexity might have led to a more homogenous group of patients who need to be quickly seen by a physician.

CONCLUSIONS

In children presenting with infectious symptoms, the performance of the MTS was lower for those with a chronic illness than in those without a chronic illness. Particularly for children with a cardiovascular illness, respiratory illness, gastrointestinal illness, or another congenital or genetic defect, nurses should bear in mind that the prioritizing of the MTS might be suboptimal.

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