Abstract

Objectives: The objective was to validate the clinical dehydration scale (CDS) for children with gastroenteritis in a different pediatric emergency department (ED) from where it was initially derived and validated.

Methods: A prospective cohort study was performed in a tertiary care pediatric ED over a 1-year period. A sample of triage nurses were trained in applying the CDS. The CDS consists of four clinical characteristics (general appearance, eyes, mucous membranes, and tears), each of which are scored 0, 1, or 2 for a total score of 0 to 8, with 0 representing no dehydration; 1 to 4, some dehydration; and 5 to 8, moderate/severe dehydration. Children 1 month to 5 years of age with vomiting and/or diarrhea who had the CDS documented at triage and a final diagnosis of gastroenteritis, gastritis, or enteritis were enrolled. Exclusion criteria included a chronic disease, treatment with intravenous (IV) rehydration within the previous 24 hours, visit to the ED for the same illness in the 7 days prior to arrival, and diarrhea of more than 10 days’ duration. The primary outcome was the length of stay (LOS) in the ED from the time of seeing a physician to discharge, analyzed with a Kruskal-Wallis test.

Results: From April 2008 to March 2009, 150 patients with a mean (±SD) age of 22 (±14) months (range = 4 months to 4 years) were enrolled. Fifty-six patients had no dehydration, 74 had some dehydration, and 20 had moderate/severe dehydration. The median LOS in the ED after being seen by a physician was significantly longer as children appeared more dehydrated according to the CDS: 54 minutes (interquartile range [IQR] = 26–175 minutes), 128 minutes (IQR = 25–334 minutes), and 425 minutes (IQR = 218–673 minutes) for the no, some, and moderate/severe dehydration groups, respectively (p < 0.001).

Conclusions: The CDS has been further validated in children with gastroenteritis in a different pediatric center than the original one where it was developed. It is a good predictor of LOS in the ED after being seen by a physician.

Keywords: gastroenteritis, dehydration, child, validation studies, scale

Parents of children with acute gastroenteritis are frequently concerned about dehydration. Clinicians usually rely on their clinical assessment to determine the magnitude of dehydration. However, it has been demonstrated that clinical judgment has poor accuracy when compared to dehydration measured by the percentage loss of body weight. Over the years, scales to measure the degree of dehydration have been developed, but without using formal recognized measurement methodology. Recently, the clinical dehydration scale (CDS) was developed following such methodology in a prospective cohort of 137 children presenting with symptoms of gastroenteritis to a pediatric emergency department (ED) of a tertiary care hospital.

The CDS for children consists of four clinical characteristics, each scored as 0, 1, or 2 for a total score of 0 to 8: 0 represents no dehydration; 1 to 4, some dehydration; and 5 to 8, moderate/severe dehydration (Table 1). After initial demonstration of internal validity, reliability, discriminatory power, and responsiveness to change, the scale was further studied in a prospective cohort of 205 children 1 month to 5 years of age presenting to the same pediatric ED. In the
latter study, the three categories of increasing dehydration (none, some, moderate/severe) were positively associated with a longer length of stay (LOS) in the ED, as well as the perceived need for intravenous (IV) fluid rehydration.9

To determine the generalizability of the scale, the next methodologic step is to determine its external validity in a setting different from the one in which it was developed, which is the objective of this study. Our hypothesis was that there would be a strong association between the three CDS categories and LOS in the ED from the time the attending physician first saw the patient until discharge, as well as an association with the perceived need for IV fluid administration. As children have a higher CDS, we expect them to stay in the ED longer and for more of them to receive IV rehydration.

### METHODS

#### Study Design

This study was a prospective cohort with a convenience sample of children aged 1 month to 5 years with a diagnosis of acute gastroenteritis as determined by the pediatric emergency physician (EP). Experienced triage nurses evaluated dehydration using the CDS for children. The study was approved by the institutional review board.

#### Study Setting and Population

The study was conducted at a tertiary care pediatric ED with approximately 60,000 visits annually, staffed mostly by pediatric EPs and some general pediatricians and family physicians. Triage is performed by the triage nurse using the computerized version of the Pediatric Canadian Triage and Acuity Scale (ped-CTAS)10,11: Level 1 represents patients needing resuscitation, while Levels 2, 3, 4, and 5 represent patients needing urgent, semi-urgent, or nonurgent care, respectively. For patients with vomiting and/or diarrhea without abdominal pain, triage nurses may start oral rehydration without medical orders.

Children with the following inclusion criteria were eligible for the study: age 1 month to 5 years; discharge diagnosis of acute gastroenteritis, gastritis, or enteritis in the computerized ED database; and the CDS recorded on a standardized form at the time of triage by the triage nurse. The exclusion criteria were any cause of dehydration other than a presumed diagnosis of gastroenteritis (because the CDS was derived only in patients with gastroenteritis), a chronic disease (renal, gastrointestinal, cystic fibrosis, malnutrition, failure to thrive), treatment with IV rehydration within the previous 24 hours, visit to the ED for the same illness in the 7 days prior to arrival, and diarrhea lasting more than 10 days.

#### Data Extraction

Data extraction was performed by an investigator not blinded to the study hypothesis but blinded to the dehydration score assigned to the patient. The data abstractor used a standardized data sheet to gather the following information: age and sex, chief complaint, length of illness, triage level, LOS in the ED after the attending physician examined the patient, total LOS in the ED, disposition, and whether the physician prescribed oral or IV fluid rehydration. We also documented blood tests including serum bicarbonate or CO₂. The normal value in our laboratory for serum bicarbonate or CO₂ is >18 mmol/L. The LOS from the time of seeing an attending physician to discharge in the ED was defined as time between being

### Study Protocol

**Clinical Dehydration Scale.** Participating nurses attended a training session on the CDS before the beginning of the study. They each had more than 1 year of work experience in the ED, training in triage, and a formal evaluation by a specialized nurse educator. They were asked to complete the CDS for any patients between the age of 1 month to 5 years with vomiting, diarrhea, or both. However, they did not have access to the inclusion or exclusion criteria at the time of scoring the patients; they only had the score sheet. The CDS assessment took 1–2 minutes to complete. The tears component was scored based on observation and history. Residents and attending physicians did not know which patients had the CDS completed in triage and did not have access to the score. Also, nurses, residents, and attending physicians were blinded to the study objectives and hypothesis.

**Identification of Eligible Patients.** All patients for whom a CDS standardized form was completed were identified and considered eligible. Of these, patients with a final diagnosis of gastroenteritis, enteritis, or gastritis were identified through the computerized ED database. These records were then reviewed manually to assess for inclusion and exclusion criteria.

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### Table 1

CDS for Children (Total Score From 0 to 8)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>General appearance</td>
<td>Normal</td>
<td>Thirsty, restless or lethargic but irritable when touched</td>
<td>Drowsy, limp, cold, or sweaty, +/- comatose</td>
</tr>
<tr>
<td>Eyes</td>
<td>Normal</td>
<td>Slightly sunken</td>
<td>Very sunken</td>
</tr>
<tr>
<td>Mucous membranes (tongue)</td>
<td>Moist</td>
<td>Sticky</td>
<td>Dry</td>
</tr>
<tr>
<td>Tears</td>
<td>Tears</td>
<td>Decreased tears</td>
<td>Absent tears</td>
</tr>
</tbody>
</table>

A score of 0 represents no dehydration; a score of 1 to 4, some dehydration; and a score of 5 to 8, moderate/severe dehydration. CDS = clinical dehydration scale.
seen by an attending physician and time of discharge or time of decision to admit to the general pediatrics inpatient unit. Total LOS in the ED was defined as time from arrival to the time of discharge or time of decision to admit.

**Inter-rater Agreement.** Inter-rater agreement was measured between the data abstractor and another investigator in 10% of the reviewed charts. The Bland and Altman method was used to assess agreement for the primary outcome.12

**Outcomes.** The primary outcome was the association between the CDS for children and the LOS in the ED after being seen by the attending physician. Secondary outcomes included associations between the CDS for children and the total LOS in the ED; the proportion of patients who received oral rehydration (defined as rehydration recorded as an order in the chart—this excluded cases for whom the rehydration was started by nurses on their own initiative), had successful oral rehydration (defined as initially started on oral rehydration without perceived requirement for IV rehydration during their ED stay), or had IV rehydration; had blood tests performed; had abnormal bicarbonate or CO2; and the distribution of the triage categories.

**Data Analysis**

Data were entered into a spreadsheet (Excel 2007, Microsoft Corp., Redmond, WA). Statistical analysis was carried out with SPSS for Windows (version 16.0.2, SPSS Inc., Chicago, IL). Baseline characteristics were analyzed using descriptive statistics. Primary and secondary outcomes were analyzed using descriptive statistics, including age (mean and standard deviation [SD]), sex (proportion), symptom duration (median and interquartile range [IQR]), LOS after being seen by an attending physician and total LOS (median and IQR), oral rehydration, successful oral rehydration and IV rehydration (proportion), length of IV rehydration (median and IQR), blood tests obtained (proportion), CO2 (median and IQR), abnormal CO2 or abnormal bicarbonate (proportion), triage category (proportion), and admission rate (proportion). The analysis of variance test was used to analyze the age by dehydration category. A Kruskal-Wallis test was used to analyze the LOS after being seen by a physician, the total LOS, the length of IV rehydration, and CO2 results among the different dehydration categories because of the nonnormal distribution of these variables. The Mann-Whitney test was then used to evaluate each pair of CDS categories when a difference was found between continuous variables. Chi-square was used to evaluate the association of sex, oral rehydration, successful oral rehydration, IV rehydration, blood tests obtained, abnormal CO2 or abnormal bicarbonate or CO22, and triage category with the dehydration category. Chi-square was also used to evaluate each pair of CDS categories when a difference was found between proportions. A Fisher exact test was used to analyze the distribution of hospital admissions according to dehydration category. The 95% confidence intervals (CIs) were calculated for all results.

**Sample Size.** The study was performed on a convenience sample of children with gastroenteritis. We decided a priori to enroll at least 100 patients to have more patients in the moderate/severe dehydration group than in the validation study;9 previous studies have reported that approximately 10% of the children with gastroenteritis presented with moderate to severe dehydration.7,9

**RESULTS**

Between April 1, 2008, and March 31, 2009, a total of 279 children had a measurement of dehydration severity using the CDS in triage (Figure 1). Of the 150 patients included in the analysis, the final diagnosis was gastroenteritis in 113 (75%), enteritis in nine (6%), and gastritis in 28 (19%). The mean (±SD) age was 22 (±14) months (range = 4 months to 4 years), and 78 were boys (52%). The median symptom duration was 48 hours (IQR = 14–72). The distribution of the CDS in children included in the analysis is presented in Figure 2: 56 were in the no dehydration category (score 0), 74 in the some dehydration (score 1–4) category, and 20 in the moderate/severe dehydration (score 5–8) category. A trial of oral rehydration was ordered by a physician in 58 patients (39%), and 41 patients (27%) received IV rehydration. A total of 146 patients (97%) were discharged home; only four patients were hospitalized, for 17, 46, 52, and 69 hours.

The study outcomes are presented in Table 2. The median LOS in the ED after being seen by an attending physician and the total LOS were significantly longer for the moderate/severe dehydration group compared...
to children with some dehydration or no dehydration. More patients in the moderate/severe dehydration group had a perceived need for IV rehydration and had laboratory tests ordered compared to the other groups. Furthermore, the CDS for children had a strong association with the assigned triage category. As expected, there was also a trend toward failure of oral rehydration as patients became more dehydrated. Of note, abnormal laboratory results were not significantly different across the different categories of dehydration. No patient had a sodium lower than 130 mmol/L or higher than 150 mmol/L. The small number of hospital admissions limited the ability to determine an association between disposition and the dehydration categories.

The inter-rater agreement was excellent according to the Bland-Altman method: the mean bias for the primary outcome was 0.5 minutes (95% CI = 2 to 3 minutes), with upper and lower limits of agreement of 11 (95% CI = 6 to 16) and -10 (95% CI = -15 to -5) minutes, respectively.

**DISCUSSION**

To the best of our knowledge, only one dehydration scale for children with acute gastroenteritis has been derived and validated according to recognized measurement methodology. Since its publication, it has

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**Table 2**

Characteristics of the Children Enrolled in the Study and Association With the Dehydration Categories of the CDS (n = 150)

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Dehydration (Score 0) (n = 56)</th>
<th>Some Dehydration (Score 1 to 4) (n = 74)</th>
<th>Moderate/severe Dehydration (Score 5 to 8) (n = 20)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, months (mean ± SD)</td>
<td>21 ± 15</td>
<td>23 ± 14</td>
<td>22 ± 11</td>
<td>0.79</td>
</tr>
<tr>
<td>Male [n (%)]</td>
<td>27 (48)</td>
<td>39 (53)</td>
<td>12 (60)</td>
<td>0.65</td>
</tr>
<tr>
<td>Symptoms duration, hours [median (IQR)]*</td>
<td>24 (8–72)</td>
<td>48 (18–76)</td>
<td>72 (48–96)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ped-CTAS triage category [n (%)]†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>3 (15)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10 (18)</td>
<td>46 (62)</td>
<td>16 (80)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>42 (75)</td>
<td>27 (36)</td>
<td>1 (5)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4 (7)</td>
<td>1 (1)</td>
<td>0 (0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LOS after physician, minutes [median (IQR)]‡</td>
<td>54 (26–175)</td>
<td>128 (25–334)</td>
<td>425 (218–673)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total LOS, minutes [median (IQR)]§</td>
<td>300 (189–456)</td>
<td>334 (182–480)</td>
<td>580 (304–860)</td>
<td>0.01</td>
</tr>
<tr>
<td>Admission [n (%)]II</td>
<td>0 (0)</td>
<td>2 (3)</td>
<td>2 (10)</td>
<td>II</td>
</tr>
<tr>
<td>Oral rehydration in ED [n (%)]</td>
<td>19 (34)</td>
<td>29 (39)</td>
<td>10 (50)</td>
<td>0.44</td>
</tr>
<tr>
<td>Success with oral rehydration [n (%)]</td>
<td>17.19 (90)</td>
<td>22.29 (76)</td>
<td>5.10 (50)</td>
<td>0.06</td>
</tr>
<tr>
<td>IV rehydration in ED [n (%)]*</td>
<td>5 (12)</td>
<td>23 (32)</td>
<td>13 (69)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length of IV rehydration in ED [median (IQR)]</td>
<td>470 (355–652)</td>
<td>450 (315–570)</td>
<td>555 (352–885)</td>
<td>0.52</td>
</tr>
<tr>
<td>Laboratory tests performed [n (%)]**</td>
<td>11 (20)</td>
<td>36 (49)</td>
<td>16 (80)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CO₂ [median (IQR)]</td>
<td>19.8 (17.2–20.5)</td>
<td>17.9 (16.2–20.1)</td>
<td>17.3 (16.0–20.1)</td>
<td>0.19</td>
</tr>
<tr>
<td>CO₂ &lt; 18 mmol/L [n (%)]</td>
<td>4/11 (36)</td>
<td>18/35 (51)</td>
<td>9/14 (64)</td>
<td>0.38</td>
</tr>
<tr>
<td>Bicarbonate or CO₂ &lt; 18 mmol/L [n (%)]</td>
<td>4/11 (36)</td>
<td>20/37 (54)</td>
<td>10/15 (67)</td>
<td>0.31</td>
</tr>
</tbody>
</table>

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When the initial statistical test found a difference between groups (p-value column), a chi-square test or Mann-Whitney test was used to examine where the difference was.

IQR = interquartile range; LOS = length of stay; ped-CTAS = Pediatric Canadian Triage and Acuity Scale.

*No versus some dehydration, p = 0.007; some versus moderate/severe dehydration, p = 0.04; no versus moderate/severe dehydration, p < 0.001.

†No versus some dehydration, p < 0.001; some versus moderate/severe dehydration, p < 0.001; no versus moderate/severe dehydration, p < 0.001.

‡No versus some dehydration, p = 0.08; some versus moderate/severe dehydration, p = 0.003; no versus moderate/severe dehydration, p < 0.001.

§No versus some dehydration, p = 0.62; some versus moderate/severe dehydration, p = 0.007; no versus moderate/severe dehydration, p = 0.004.

‖No versus some dehydration, p = 0.32; some versus moderate/severe dehydration, p = 0.17; no versus moderate/severe dehydration, p = 0.07 (by Fisher exact test).

*No versus some dehydration, p = 0.005; some versus moderate/severe dehydration, p = 0.005; no versus moderate/severe dehydration, p < 0.001.

**No versus some dehydration, p < 0.001; some versus moderate/severe dehydration, p = 0.005; no versus moderate/severe dehydration, p = 0.01.
been validated in the same ED. This study showed that the dehydration categories as suggested by the CDS for children were associated with the LOS in the ED, treatment rate with IV fluids, and the number of vomiting episodes in the 7 days before the ED visit.

Our study showed that the CDS for children is a good predictor of 1) LOS in the ED after being seen by a physician, 2) perceived need for IV rehydration, and 3) utilization of laboratory blood tests. Our results are quite similar to the initial validation study. The main difference appears to be the lower rate of oral rehydration in our study. This can be explained by the fact that in our study we considered oral hydration to have taken place only if a physician order was written in the patient’s chart and did not include patients for whom the nurses started this process in triage. This may have decreased the recorded rate of oral rehydration in our study.

Our study is the first to address the question of external validation of the CDS for children. We selected our outcome measure a priori as LOS in the ED from the time of being seen by an attending physician to discharge instead of the total LOS in the ED to limit the effect of the confounding factor of time spent waiting to be seen by an attending physician, which is often high in our ED. This explains the high rate of patients who left without being seen by a physician in our study, which is, however, lower than the rate over 1 year that we reported in another study for all patients, not only those with symptoms of gastroenteritis. In our study, the three CDS categories were associated with a significantly different duration of symptoms, rate of IV rehydration, utilization of laboratory blood testing, and triage category. The latter result suggests that the CDS is in accordance with the pediatric CTAS triage tool. The three CDS categories also show a trend toward decreasing success of oral rehydration as the dehydration categories become more severe. A low bicarbonate or a low CO₂ were unhelpful in distinguishing between the groups. This is not surprising as laboratory tests are said in general to only be helpful when they are markedly abnormal. In that regard, our results are similar to those of the CDS initial validation study.

The use of a dehydration scale in an ED has several advantages. First, it allows triage nurses to correctly identify patients with more severe dehydration. Second, it may permit, if used appropriately in clinical practice guidelines, the initiation of investigation and treatment before patients are initially assessed by the ED physicians. This may be advantageous in the busy ED and may lead to decrease in LOS. For example, all patients with a score of 5 to 8, the moderate/severe dehydration group, could have the appropriate blood tests performed and an IV started in triage, while patients with a score of 1 to 4 (the some dehydration group) could be started on oral rehydration while waiting for a physician assessment. Third, the CDS could decrease practice variation among physicians by standardizing the measurement of dehydration. The next steps should include a multicenter validation in EDs from community, rural, and general hospitals, as well as incorporating the CDS into a clinical practice algorithm to manage acute gastroenteritis in children less than 5 years of age.

LIMITATIONS

Not all eligible patients presenting to the ED were recruited. Because only approximately 25% of all triage nurses were taught the CDS, and the application of the scale was not mandatory, not all patients with symptoms of gastroenteritis had the scale recorded and could be entered in the study. It is difficult to evaluate the number of eligible patients missed based on the final diagnosis of gastroenteritis, because of the number of exclusion criteria. However, we have no reason to suspect that the included children were any different from those missed.

The sample size was not formally calculated to test a hypothesis. It was solely based on the desire to have more patients in the moderate/severe dehydration group than in the previous validation study. However, the demonstration of a statistically significant difference limits power calculation usefulness. More importantly, our pediatric ED is similar to the one in which the CDS was developed and first validated. Both are busy tertiary care pediatric hospitals in large Canadian cities and are staffed similarly. However, the nurses performing triage in our study were naive to the objectives of the study and to the previous performance of the scale. Furthermore, as mentioned earlier, physicians did not know which patients had the dehydration scale completed in triage and did not have access to the score. These factors significantly reduce the potential bias in our study.

We could not evaluate the scale according to the severity of the symptoms because most physicians did not record the total number of vomiting and diarrhea episodes in the charts. However, we did find that patients in the moderate/severe dehydration group had symptoms for a longer period of time than those who were in the same dehydration and no dehydration group, respectively (Table 2). Overall LOS may be influenced by multiple factors, including how busy the ED was at the time of the visit. By using the LOS starting at the time of being seen by a physician, we decreased the effect of these confounding factors.

Furthermore, our study evaluated concurrent validity, the quality of a measure evaluating the association between the score, and other factors that are likely to be associated with the severity of illness (such as LOS, use of blood tests, and the perceived need for IV rehydration). We did not evaluate the criterion validity that would have required the weight measurement of patients once their symptoms had resolved, weight difference being generally accepted as the criterion standard to determine the degree of dehydration. This was, however, performed in the initial development process of the CDS.

Finally, while there was a strong association between CDS and all outcomes in general, there were some situations that failed to reach a statistical difference between the no dehydration and the some dehydration groups. This may be related to multiple testing, because it increases the risk of Type II error.
CONCLUSIONS

The clinical dehydration scale for children is a good predictor of length of stay after being seen by an attending physician in the ED in children with gastroenteritis in a pediatric center different from the original center where it was developed. The scale is also a good predictor of the overall length of stay in the ED, the use of laboratory blood tests, and the use of IV rehydration in those children.

References