How Commonly Are Children Hospitalized for Dehydration Eligible for Care in Alternative Settings?

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Background: Avoiding unnecessary hospitalization has long been a goal of child health care providers. Managed care practice environments increasingly pressure the practicing pediatrician to avoid hospitalization.

Objectives: To estimate the proportion of childhood dehydration hospitalizations eligible for care in alternative settings (eg, short-stay treatment and triage units, home nursing) and to assess the type and duration of services that might be required for alternative setting care of children with these illness episodes.

Design: All dehydration hospitalizations for the 198,593 children (aged >1 month and <19 years) dwelling in Rochester, NY (Monroe County), between 1991 and 1995 were identified in county-wide hospital discharge computer files. Medical records were reviewed for a random sample of 380 of the hospitalizations. Children with major underlying conditions were excluded from analysis because of higher risk for deterioration, and greater complexity of medical care might render alternative settings inappropriate. Measures included a 4-item score estimating level of dehydration, serum bicarbonate level at presentation, and time to rehydration. Rehydration was defined as a drop in urine-specific gravity to 1.010 or less or reduction of fluid administration to the maintenance rate.

Results: Altogether, 1121 dehydration hospitalizations occurred during the study period. Based on medical record review for a random sample of 380 of these 1121, major underlying problems were present in 27.4% (104) of hospitalizations sampled. Simple, acute gastroenteritis accounted for 75.4% (208) of 276 hospitalizations remaining in the sample. Levels of dehydration for these children were estimated as at least 5% for 51.0% (106) and at least 10% for 16.3% (34) of hospital admissions, and serum bicarbonate levels were 12 mmol/L or less for 26.0% (54). Time from hospital admission to rehydration was no greater than 12 hours for 79.3% (165) and no greater than 24 hours for 94.7% (197). However, hospital stay was generally substantially longer. The time hospitalized following rehydration represented 85.8% of the average inpatient stay. Hospital discharge was heavily concentrated in daytime hours, although the children achieved rehydration at all hours of the day. No deterioration occurred during hospitalizations studied.

Conclusion: Nearly all children hospitalized for simple, acute gastroenteritis in Rochester might be eligible for care in alternative settings designed to provide hospital-level care for short periods.


Editor's Note: The hospital is no place for a child (or anyone else) who is not severely ill. The development of 24-hour outpatient units would eliminate a lot of unnecessary hospitalization time for dehydration and probably numerous other problems. Catherine D. DeAngelis, MD

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Gastroenteritis and dehydration account for a large proportion of childhood hospitalizations. In US children younger than 5 years, 220,000 hospitalizations are attributed to diarrhea. These represent 9% of all hospitalizations for this age group. In 1992, among California children aged 1 through 5 years, gastroenteritis and dehydration accounted for 10.6% of hospital discharges, ranking second to asthma, which accounted for 12.8%. Estimates based on recent observations in a large children’s hospital in Texas indicated that rotavirus, the most common etiology of gastroenteritis among children, produces 110,000 hospital admissions annually in the United States at a cost of $352 million. In the setting for the present study, Rochester, NY (Monroe County), gastroenteritis and dehydration was the third most common medical reason for hospital admission between 1994 and 1996 among children older than 1 month and younger than 19 years. This problem accounted for 3.9% of all childhood hospi-
SUBJECTS AND METHODS

We conducted a descriptive study based on analysis of medical record reviews of a random sample of dehydration hospitalizations as well as hospital discharge files. The sampling frame for the medical record reviews included all of the hospitalizations between 1991 and 1995 (N = 28,047) for children (aged 1 month and <19 years) who were residents of Monroe County (Rochester), NY. No programs designed to replace pediatric hospitalizations were active or developing during the study period. Hospital discharge data were obtained from the Rochester hospitals' database, a data set developed and maintained cooperatively by all Rochester-area hospitals. Among these hospital discharges, there were 1121 with a primary diagnosis suggesting dehydration. Dehydration hospitalizations were identified by a primary hospital discharge diagnosis coded according to the International Classification of Diseases, Ninth Revision indicating gastroenteritis due to a specific agent, nonspecific viral gastroenteritis, noninfectious gastroenteritis or diarrhea, hypovolemia, or diarrhea. The following International Classification of Diseases codes falling in these clinical groups were encountered: 0030.0, 004.0, 004.3, 004.8, 004.9, 008.0, 008.00, 008.43, 008.45, 008.49, 008.5, 008.6, 008.61, 008.67, 008.69, 008.8, 009.0, 009.1, 276.5, and 558.9. Admissions with a primary hospital discharge diagnosis indicating vomiting alone (codes 787.0-787.03) were excluded for several reasons. The number of these vomiting hospitalizations (n = 16) was small compared with the number that met the definition of dehydration hospitalizations (1121). In our clinical experience, some children with simple, acute gastroenteritis manifest their illness primarily with vomiting at the time they are hospitalized, but before they are discharged from the hospital, they usually develop diarrhea as well; therefore, they receive a hospital discharge diagnosis of acute gastroenteritis. We believe that children who at hospital discharge have yet to develop illness manifestations that would support a diagnosis more specific than vomiting probably did not have acute gastroenteritis. They probably had an illness associated with a high level of diagnostic uncertainty, and thus might not make good candidates for care in alternative settings.

Dehydration episodes in children with no major underlying chronic problem were labeled as dehydration and no chronic problem. Dehydration and no chronic problem included 3 subgroups, 2 of which were based on the causes of dehydration that were apparent at the time of hospital admission. These 2 subgroups included children whose dehydration was attributed to simple, acute gastroenteritis, generally viral, and children whose dehydration was attributed to some other acute problem, such as oral infection (eg, gingivostomatitis, pharyngitis) or recent tonsillectomy. The final subgroup, native settings might include short-stay treatment and triage centers (or observation units), home nursing care, and sick-child day care. Extensive experience in the use of treatment and triage centers for avoidance of hospitalizations for acute asthma exacerbation has been reported. Innovations in the treatment of dehydration, particularly oral rehydration, may facilitate avoidance or replacement of dehydration hospital admissions.

The primary objectives for this study were (1) to estimate the proportion of childhood dehydration hospitalizations eligible for care in alternative settings and (2) to assess the type and duration of services required for the care of these illness episodes, irrespective of setting. An important methodological challenge in meeting these
diagnostic uncertainty, was characterized at the time of presenta-
tion by uncertainty about diagnosis and considera-
tion of a serious acute problem (eg, appendicitis) other than dehydration.

To allow generalizability to alternative care settings to be assessed, severity of fluid and electrolyte derange-
ment was characterized by the level of dehydration and pres-
ence of acidosis and hypernatremia. Severe hypernatremia and severe acidosis were defined, respectively, by serum sodium values greater than 150 mmol/L and serum bicar-
bonate values of 12 mmol/L or less. Level of dehydration was based on a 4-item scale, recently described by Gorelick et al, and on the presence of acidosis or hypernatremia. The 4 items on the Gorelick scale are ill appearance, cap-
illary refill more than 2 seconds, absent tears, and dry muc-
cous membranes. Based on this scale, moderate or greater dehydration (5% dehydrated) was defined as 2 or more of these findings, and severe dehydration (10% dehydrated) was defined as 3 or more findings. Using rehydration weight as the criterion standard, Gorelick et al found sensitivity and specificity of this scale for 5% dehydration to be 0.79 and 0.87, respectively. For 10% dehydration, sensitivity and specificity were 0.82 and 0.83, respectively. Any item on the severity scale that was not mentioned in the medical record was assumed to be normal. Clinical observations in emergency departments at which children presented were made by house staff and attending physicians. House staff were supervised by attending physicians at all times. Un-
like observations performed by Gorelick et al while develop-
ning and validating their scale, there was no attempt to standardize observations through procedures, such as using a stopwatch while assessing capillary refill.

Several measures addressed the potential for care in alter-
native settings, including time to rehydration, hospital length of stay, and hospital stay beyond rehydration. Times were measured in 4-hour periods. Four-hour periods were chosen as the unit of time because the point at which key ob-
servations were made, while often somewhat ambiguous in medical records, could almost always be placed within the first or second half of a standard, 8-hour nursing shift. Nurs-
ing shifts, in general 8 hours long, measure a critical health care resource. Four-hour periods were converted to hours to simplify the presentation of results. Observations were ab-
stracted from medical records for as many as 24 periods (4 days). Nearly all (96.0%) (n = 265) hospital admissions for dehydration and no chronic problem lasted less than 4 days.

The primary outcome measure, rehydration, was cho-
sen because it represents a cardinal index of physiologic sta-
bility in children with dehydration. Once rehydration has been achieved, the treatment of children presenting with simple, acute dehydration generally is straightforward, with the pri-
mary focus usually becoming the administration of suffi-
cient fluids to meet maintenance requirements and to re-
place ongoing losses. Achievement of rehydration was based on observations of urine-specific gravity and on fluid admin-
istration rate. A child was considered to be hydrated in the first 4-hour period when (1) isotonic or more dilute urine was documented, or (2) the rate of intravenous (IV) fluid ad-
mistration was reduced to the maintenance rate. During the study period, urine-specific gravity was measured only by re-
fractometer. The maintenance fluid rate was estimated for each child by the Holiday-Segar method. The maintenance IV fluid rate was reached when IV fluids were reduced to a rate that was no greater than 5 mL/h above the maintenance rate. Un-
intentional interruptions in IV fluid administration, due to fluid infiltration, for example, were not counted as reduc-
tions in fluid administration.

Several clinical situations were of particular interest be-
cause they might present special challenges to care in alter-
native settings. These included severe dehydration, severe hypernatremia, severe acidosis, and critical care unit (CCU) transfers. Many clinicians might be unwilling to care for a child in alternative settings until it was clear that such con-
ditions were resolving. Severe dehydration, severe hyperna-
 tremia, and severe acidosis are defined above. A CCU trans-
fer was defined by admission of a child initially to a regular inpatient unit, followed by transfer to the pediatric CCU. A CCU transfer, when it occurs, is often an appropriate re-
response to deterioration despite usual inpatient care. Deterio-
ration during care in alternative settings obviously is unde-
sirable, even though careful monitoring in such settings should prevent adverse physical outcomes.

ANALYSIS

Denominators for calculation of county-wide hospitaliza-
tion rates were based on the 1990 US census. Over the 5-year observation period, the 198 593 children younger than 19 years in the 1990 census accounted for 992 965 child-years at risk. The t test was used to assess statistical significance for differences between 2 means, and the F test was used to assess significance for differences among multiple means.

RESULTS

HOSPITALIZATION FOR DEHYDRATION

During the study period, 1121 hospitalizations in Mon-
roe County were attributed to dehydration, yielding a hospitalization rate of 1.13 (95% confidence interval, 1.06-1.93) per 1000 child-years. Table 1 displays the frequencies of primary hospital discharge diagnoses among all dehydration hospital admissions and in the medical record sample. As shown in Figure 1, among

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the 380 records reviewed, 104 (27.4%) were excluded from the primary analysis because a major underlying condition contributed directly to the dehydration or may have impaired physiologic resilience. Many of these children had multiple chronic problems. The 10 most common chronic problems included failure to thrive and feeding disorders, 17; neuromuscular disorders (eg, cerebral palsy, congenital quadriplegia, Werdnig-Hoffmann disease, hydrocephalus), 16; seizure disorder, 13; asthma and bronchopulmonary dysplasia, 8; malignancy, 8; chronic renal disease, 7; chronic liver disease, 6; congenital heart disease, 5; postsurgical states (eg, gastrostomy, ileostomy), 5; and endocrine and/or metabolic disorders, 4. The remaining 276 illness episodes included the group with dehydration and no chronic problem. Assuming the number of children with underlying problems occurred among all dehydration hospitalizations in the same proportion that they occurred in the record review sample, the county-wide hospitalization rate for dehydration and no chronic problem was estimated as 0.82 (95% confidence interval, 0.76-0.87) per 1000 child-years.

The mean (SD) ages of all children hospitalized with dehydration and those in the record review sample were 4.4 (5.2) and 4.2 (4.8) years, respectively. Sex distributions among all children hospitalized and those in the record review sample were also similar, with males constituting 53.9% (604) overall and 55.3% (210) in the sample.

HOSPITALIZATION FOR DEHYDRATION AMONG CHILDREN WITH NO CHRONIC PROBLEM

Among the 276 children most likely to be candidates for care in alternative settings—those with dehydration and no major chronic problem—the diagnosis was apparent at the time of hospital admission for most, including the 208 (75.4%) with simple, acute gastroenteritis and the 25 (9.5%) with other acute problems. Children with other acute problems included 3 who were dehydrated following tonsillectomy, 14 with oral (eg, gingivostomatitis) or pharyngeal (eg, streptococcal pharyngitis) conditions that interfered with oral intake, and 8 with viral syndromes associated with vomiting. For the remaining 43 (15.6%), diagnostic uncertainty at the time of hospital admission appeared to be an important factor in justifying the hospitalization. Diagnostic considerations for these 43 included appendicitis, 21; bacterial gastroenteritis, 3; other serious bacterial infection (eg, sepsis, urinary tract infection), 11; and a diverse group of other problems, 8. Males predominated (56.9%) (n = 118) among 208 children with simple, acute gastroenteritis. Differences in sex

<table>
<thead>
<tr>
<th>Primary Hospital Discharge Diagnosis</th>
<th>All Dehydration Hospital Discharges, No. (%)</th>
<th>Total in Sample, No. (%)</th>
<th>Major Chronic Problem, No. (%)</th>
<th>Medical Record Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD Code</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0030. Salmonella enteritis</td>
<td>11 (1.0)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>004.0 Shigella dysenteriae</td>
<td>1 (0.1)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>004.3 Shigella sonnei</td>
<td>4 (0.4)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>004.8 Shigella infection NEC</td>
<td>1 (0.1)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>004.9 Shigellosis NOS</td>
<td>5 (0.4)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>008.0 Eschericia coli enteritis NEC</td>
<td>1 (0.1)</td>
<td>1 (0.3)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>008.00 Intestinal infection, Eschericia coli</td>
<td>5 (0.4)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>008.43 Intestinal infection</td>
<td>2 (0.2)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>008.45 Intestinal infection, Clostridium</td>
<td>7 (0.6)</td>
<td>1 (0.3)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>008.49 Bacterial enteritis NEC</td>
<td>5 (0.4)</td>
<td>1 (0.3)</td>
<td>1</td>
<td>...</td>
</tr>
<tr>
<td>008.5 Bacterial enteritis NOS</td>
<td>3 (0.3)</td>
<td>3 (0.8)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>008.6 Viral enteritis NEC</td>
<td>27 (2.4)</td>
<td>11 (2.9)</td>
<td>1</td>
<td>...</td>
</tr>
<tr>
<td>008.61 Intestinal infection, Rotavirus</td>
<td>21 (1.9)</td>
<td>2 (0.5)</td>
<td>1</td>
<td>...</td>
</tr>
<tr>
<td>008.67 Intestinal infection, Enterovirus</td>
<td>1 (0.1)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>008.69 Other viral intestinal infection</td>
<td>1 (0.1)</td>
<td>0 (0)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>008.8 Viral enteritis NOS</td>
<td>246 (21.9)</td>
<td>98 (25.8)</td>
<td>29</td>
<td>49</td>
</tr>
<tr>
<td>009.0 Infectious enteritis NOS</td>
<td>3 (0.3)</td>
<td>1 (0.3)</td>
<td>1</td>
<td>...</td>
</tr>
<tr>
<td>009.1 Enteritis of infectious origin</td>
<td>2 (0.2)</td>
<td>2 (0.5)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>276.5 Hypovolemia</td>
<td>588 (52.5)</td>
<td>195 (51.3)</td>
<td>45</td>
<td>121</td>
</tr>
<tr>
<td>558.9 Noninfectious gastroenteritis NEC</td>
<td>187 (16.7)</td>
<td>65 (17.1)</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>1121 (100.0)</td>
<td>380 (100.0)</td>
<td>104</td>
<td>208</td>
</tr>
</tbody>
</table>

*ICD indicates International Classification of Diseases, Ninth Revision; NEC, not elsewhere classified; NOS, not otherwise specified; and ellipses, not applicable.
of the "Subjects and Methods" section.

*NS indicates not significant.
†Time from registration in the emergency department to time rehydration criteria were met. Definition of rehydration is found in the "Definitions and Measures" subsection of the "Subjects and Methods" section.
‡Time from registration in the emergency department to hospital admission.
§Time from registration in the emergency department to time of hospital discharge.
¶Hospital length of stay from time of admission to an inpatient unit to time of hospital discharge.
#The mean time from rehydration to hospital discharge is equal to the difference between times from presentation to hospital discharge and presentation to rehydration. Some children were rehydrated prior to hospital admission. For children rehydrated prior to hospital admission, the time from hospital admission to rehydration was set equal to 0; the mean time from rehydration to hospital discharge is therefore slightly less than the difference between times from hospital admission to hospital discharge and hospital admission to rehydration.

## SEVERITY OF DEHYDRATION

A substantial portion of children admitted to the hospital with dehydration and no chronic problem were moderately or severely ill, as indicated by observations that 44.2% (122) were at least 5% dehydrated, 13.8% (38) were at least 10% dehydrated, 19.9% (35) had an initial serum bicarbonate value of 12 mmol/L or less, and 6.5% (18) were hypernatremic (Table 2). Also apparent in Table 2, the worst fluid and electrolyte disturbances were found among children with simple, acute gastroenteritis.

### RELATIONSHIPS BETWEEN CLINICAL OBSERVATIONS, REHYDRATION, AND HOSPITAL LENGTH OF STAY

Isotonic urine production and maintenance fluid administration identified the time that rehydration was achieved in 55.1% (152) and 44.9% (124) of illness episodes, respectively. Rehydration was achieved long before children were discharged from the hospital. As indicated in Table 2, the mean time for all children with dehydration and no chronic problem from admission to the inpatient unit to rehydration was 6.4 hours, whereas the mean time from hospital admission to hospital discharge was 44.0 hours. The severity of dehydration and time to achieve rehydration varied substantially among the dehydration subgroups, but the hospital length of stay did not. Measured from the time of admission to the inpatient unit, time to rehydration varied significantly (F_2 = 3.29, P = .04) among subgroups, but time to hospital discharge did not (F_2 = 3.68, P = .03). Mean (SD) times from hospital admission to rehydration for children estimated to be less than 0; the mean time from rehydration to hospital discharge is therefore slightly less than the difference between times from hospital admission to hospital discharge and hospital admission to rehydration.

### Table 2. Characteristics of Children With No Chronic Problem Presenting With Dehydration

<table>
<thead>
<tr>
<th>Observation</th>
<th>Simple, Acute Gastroenteritis</th>
<th>Other Acute Problems</th>
<th>Diagnostic Uncertainty</th>
<th>All 3 Subgroups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalization rates, * per 1000 (95% confidence interval)</td>
<td>0.643 (0.594-0.693)</td>
<td>0.077 (0.094-0.060)</td>
<td>0.133 (0.111-0.155)</td>
<td>0.854 (0.797-0.911)</td>
</tr>
<tr>
<td>Sample, No. (%)</td>
<td>208 (75.4)</td>
<td>25 (9.1)</td>
<td>43 (15.6)</td>
<td>276 (100.0)</td>
</tr>
<tr>
<td>Age, mean y</td>
<td>3.2</td>
<td>5.2</td>
<td>7.6</td>
<td>4.1</td>
</tr>
<tr>
<td>Seasonal predominance</td>
<td>Jan-Apr</td>
<td>None</td>
<td>None</td>
<td>Jan-Apr</td>
</tr>
<tr>
<td>Dehydration level ≥5%, %</td>
<td>51.0</td>
<td>20.0</td>
<td>25.6</td>
<td>44.2</td>
</tr>
<tr>
<td>Dehydration level ≥10%, %</td>
<td>16.3</td>
<td>8.0</td>
<td>4.7</td>
<td>13.8</td>
</tr>
<tr>
<td>Serum bicarbonate ≥12 mmol/L, %</td>
<td>26.0</td>
<td>0</td>
<td>2.3</td>
<td>19.9</td>
</tr>
<tr>
<td>Serum sodium &gt;150 mmol/L, %</td>
<td>3.4</td>
<td>0</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>Treatment times, mean (SD), h</td>
<td>13.3 (8.9)</td>
<td>10.9 (5.8)</td>
<td>9.5 (8.5)</td>
<td>12.5 (8.7)</td>
</tr>
<tr>
<td>Presentation to rehydration</td>
<td>49.6 (28.7)</td>
<td>52.8 (25.4)</td>
<td>57.9 (38.4)</td>
<td>51.1 (30.2)</td>
</tr>
<tr>
<td>Admission to rehydration</td>
<td>7.1 (8.3)</td>
<td>4.6 (5.5)</td>
<td>4.1 (7.9)</td>
<td>6.4 (8.0)</td>
</tr>
<tr>
<td>Admission to discharge</td>
<td>42.3 (28.4)</td>
<td>44.9 (24.2)</td>
<td>51.4 (38.9)</td>
<td>44.0 (30.0)</td>
</tr>
<tr>
<td>Rehydration to discharge</td>
<td>36.3 (29.0)</td>
<td>41.8 (24.4)</td>
<td>48.4 (37.3)</td>
<td>38.6 (30.3)</td>
</tr>
</tbody>
</table>

*Based on a denominator of 994 465 child-years at risk for an estimated 198 893 children (1990 US census) ages older than 1 month and younger than 19 years who were at risk for each of the 5 years of observation. For purposes of calculating rates for each of these groups, the total number of hospitalizations in each group was estimated based on the sampling fraction (0.325) and the number of hospitalizations for the group in the sample.
The subgroup with simple, acute gastroenteritis represents a large, clinically homogeneous category for which challenges of treatment are well defined. Accordingly, estimates for the potential impact of alternative settings on care for this group seemed most reliable and most useful. For children with simple, acute gastroenteritis, Figure 2 compares proportions of those remaining dehydrated and those remaining hospitalized over time. Times from presentation in the emergency department and from arrival at the inpatient unit are both used in Figure 2. These times provide upper and lower bounds for the length of hospital stay potentially avoided. The time of arrival at the inpatient unit may vary considerably with factors such as bed availability, that are unrelated to the treatment of a specific illness episode. If care in alternative settings began at the same time that the children arrived at the inpatient unit, the area between the dashed lines estimates the total avoidable hospital stay. If care in alternative settings began immediately following arrival in the emergency department, the corresponding area between the solid lines estimates the total avoidable hospital stay. In this latter example, the term hospital stay includes time spent in the emergency department.

Much of the rehydration for children with simple, acute gastroenteritis (n = 208) was accomplished in the emergency department. Eighty percent of children (166) were rehydrated within 12 hours of admission to the hospital. Mean (SD) time spent in the emergency department was 7.2 (3.8) hours. As demonstrated in comparing dashed lines in Figure 2, by the time children arrive at the inpatient unit, already 22.7% of children (47) are no longer dehydrated. Twelve hours later, only 20.7% (43) are still dehydrated, while 95.7% (199) are still hospitalized. Twenty-four hours later, only 5.3% (11) are still dehydrated, while 70.2% (146) remain hospitalized. Considering time spent and rehydration achieved in the emergency department (Figure 2, solid lines), almost half (46.2%) (n = 96) are rehydrated by 12 hours after arrival at the emergency department, whereas virtually all remain in the hospital at that time. By 24 hours from presentation, only 9.1% (19) remain dehydrated, whereas 86.1% (179) remain hospitalized. For times from presentation, the mean (SD) difference between rehydration and hospital discharge was 36.3 (29.0) hours.

Figure 2. Rehydration vs hospital stay: admissions for simple, acute gastroenteritis. If care in alternative settings began at the same time that the children arrived at the inpatient unit, the area between the dashed lines estimates the total avoidable hospital stay. If care in alternative settings began immediately following arrival in the emergency department, the corresponding area between the solid lines estimates the total avoidable hospital stay. In this latter example, the term hospital stay includes time spent in the emergency department.
most half this group), the most practical alternative to hospitalization probably would involve close proximity to such services.

Available data provided the most useful information about the potential to avoid or replace hospitalization for the large and relatively homogeneous group with dehydration due to simple, acute gastroenteritis. As demonstrated in Table 2 and Figure 2, rehydration was achieved rapidly despite the fact that large proportions in this group had dehydration that was at least moderately severe or had severe acidosis. Although the times to rehydration varied significantly by level of dehydration, the mean difference in time to rehydration between children with less than 5% dehydration and children with 10% or more dehydration was only 3.5 hours. Most notably, children with simple, acute gastroenteritis remained hospitalized for long periods after rehydration was achieved. The mean time to hospital discharge following rehydration was 36.3 (29.0) hours. This period represented 89.8% of the mean hospital stay as measured from the time of arrival in the inpatient unit to the time of hospital discharge, and 73.2% of the mean hospital stay as measured from the time of arrival in the emergency department to the time of hospital discharge (Table 2). If one assumes that entry to care in an alternative setting would probably occur at some time earlier in the course of the illness than current hospital admissions, then 73.2% and 85.8% represent the lower and upper bounds for the proportion of the hospital experience potentially eliminated for children with simple, acute gastroenteritis.

Equally important, we estimate that the proportion of hospital admissions for simple, acute gastroenteritis that might be avoided through care in alternative settings would approach 100%. The mean time from presentation to rehydration was 13.3 hours. By 24 hours after presentation, more than 90% of the patients had been rehydrated. There was no indication that entry to care in an alternative setting should be delayed until rehydration was achieved. No children admitted with simple, acute gastroenteritis received care other than oral or IV fluids and monitoring, care that could be provided readily through a home nursing service or in a short-stay unit. The mean times to achieve rehydration for children whose dehydration was 10% or more or who had severe acidosis were only marginally (<2 hours) longer than for children whose physiologic derangement was milder. Determination to the point that a child was transferred to the CCU did not occur. No child with dehydration or a chronic problem was admitted to the CCU for any portion of his or her hospital stay.

Previous reports include observations that are consistent with our findings and support our interpretations. Several studies indicate that rehydration may be achieved in less than 8 hours through either IV or oral rehydration techniques.18,30-32 Failure of oral rehydration, defined as replacement of this approach with IV therapy, has been estimated as only 3.6% (95% confidence interval, 1.4%-5.8%).30 Difficulty in predicting persistent vomiting and ongoing fluid losses from diarrhea presents a challenge in the treatment of acute gastroenteritis,26,33 but these issues could be addressed effectively in an alternative approach if careful follow-up is built in.

VALIDITY

Observations support the validity of our measure of rehydration. The level of physiologic derangement, as indicated by the level of dehydration and severity of acidosis, was greater in the group of children with simple, acute gastroenteritis than in the other 2 subgroups analyzed. Longer time to rehydration for the simple, acute gastroenteritis group would be expected on this basis. Time to rehydration was close to 3 hours longer for the children with simple, acute gastroenteritis than for children in the other 2 subgroups (Table 2), consistent with this expectation. That our measure for time to rehydration performs as expected suggests that it provides a useful index of the phenomenon it is intended to measure (return to normal fluid balance).

Time to rehydration as measured by medical record review overestimates the time required for rehydration to be achieved. Output of isotonic or more dilute urine was considered the best available index of rehydration. In persons with normal renal function, urine concentration provides a direct measure of hydration, although this index may provide a somewhat conservative estimate for the time that rehydration is achieved because of the lag between urine production by the kidneys and bladder emptying. Unfortunately for purposes of this study, urine-specific gravity was not always recorded after rehydration had apparently been achieved. Many children had no recorded urine-specific gravity for many periods before or after the time when clinical observations and treatment (eg, discontinuation of IV fluids) clearly indicated that rehydration had occurred. The second criterion for achievement of rehydration, reduction of IV fluid administration to the maintenance rate, was adopted because of this practical limitation in the use of urine concentration as the indicator for this outcome. Assuming valid clinical assessments, maintenance IV fluid administration clearly provides a conservative estimate for the time that rehydration was achieved. Considerable lag time is expected from when a child achieves rehydration to when a physician’s order to reduce IV fluid administration is implemented. Despite this lag, the time at which rehydration is achieved should be understood as a time when the level of monitoring can be reduced, not necessarily as a time for discharge from inpatient or alternative services. Diminished fluid intake and excess fluid loss commonly continues well beyond the time that rehydration is achieved.

The most important limitation is that studies with observational designs cannot provide precise estimates for the proportion of hospital admissions that could be avoided or replaced. Precise estimates can only be provided through randomized clinical trials of well-defined alternative services. End points available through medical record review provide imperfect measures of the duration of care needed in alternative settings. For example, children with simple, acute gastroenteritis are generally not yet well at the time they become rehydrated, and some of these children will not be ready for...
discharge from an alternative setting at the time rehydration is achieved. This difficulty in interpreting our findings is compounded by the fact that we have not specified a particular alternative setting. The capacity to provide particular services and the ability to respond to unforeseen events may vary among alternative settings, such as short-stay units located within the medical center and home nursing care. We also recognize that external validity is limited by our one community sample. We have focused on physiologic end points as measures of potential rather than services delivered (eg, hospital length of stay) because the biologic characteristics of children with gastroenteritis are much less likely to vary than patterns of care.

**GENERALIZABILITY**

The generalizability of our findings may be assessed by comparing distributions for levels of dehydration, serum bicarbonate, and serum sodium with those for children in other settings. It should be recognized that Gorelick’s scale, used for characterizing the level of dehydration, has been validated among children between 1 month and 5 years of age. Children in this age range constituted 81.7% (170) of the group with simple, acute gastroenteritis. Given the components of this scale (appearance, capillary refill, mucous membranes, tears), it may be valid for most of the remaining 18.3% (38) as well, but this has not been established. Children younger than 9 years constituted 91.3% (190) of those with simple, acute gastroenteritis.

**DESIGNING SERVICES TO FIT NEEDS**

Despite clear differences in severity among the 3 dehydration subgroups, there was no significant difference in hospital length of stay. Even more striking is that the time following rehydration represented 85.8% of the hospital inpatient stay. These observations suggest that factors other than physiologic derangement are key determinants of length of hospital stay. Bed availability, an issue that frequently delays hospital admissions, would generally not be a problem when admitting a child to home nursing. Although Figure 2 demonstrates that the achievement of rehydration is a continuous process, hospital discharges concentrate at certain times of the day. Figure 3 demonstrates a pattern for hospital discharge times that suggests hospital discharge is heavily influenced by physicians’ rounds schedules and office routines of attending physicians, continuity clinic schedules of residents, and work and family responsibilities of parents. Most hospital admissions (74%) occur late in the evening or in the middle of the night. Although these children are rapidly and steadily rehydrated throughout the night they are admitted and in the daylight hours that immediately follow, hospital discharges occur most commonly in the afternoon the day after hospital admission. Given current inpatient care routines, this pattern of hospital discharges is not surprising. Our clinical experience suggests that many providers are reluctant to discharge from the hospital a child with remaining illness symptoms, even when remaining symptoms would be insufficient to justify hospital admission. We speculate that if children were admitted directly from the emergency department to a home nursing service that reduction and eventual withdrawal of services for children already in their own homes would occur sooner than current hospital discharge.

**CONCLUSIONS**

Findings indicate that rehydration is rapidly achieved for virtually all children hospitalized for dehydration due to simple, acute gastroenteritis. Virtually all hospital stays for dehydration could safely be shortened or eliminated, given modest health system innovations. Given that childhood hospitalization rates in Rochester have historically been substantially lower than those of other urban communities, potentially large cost reductions in Rochester might be still larger in many other communities. In 1982, for example, the hospitalization rate for...
childhood gastroenteritis in this community was less than half that in Boston, Mass, and almost half that in New Haven, Conn. Allocation of resources for a randomized trial to estimate carefully the efficacy and quality of care alternatives may be a wise investment.

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