Hospitalization for Community-Acquired, Rotavirus-Associated Diarrhea

A Prospective, Longitudinal, Population-Based Study During the Seasonal Outbreak

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Objectives: To determine the age-specific hospitalization rate for rotavirus-associated diarrhea in Canadian children during the seasonal outbreak, and to characterize children and their households, for assessment of the need for a rotavirus vaccine.

Design: Prospective multisite cohort study.

Settings and Participants: Children with an admission diagnosis of diarrhea admitted to 18 hospitals serving 132 study census tracts of a major urban region, from November 1, 1997, through June 30, 1998. Prospective centralized testing of stools was performed; research nurses administered a follow-up questionnaire to parents.

Main Outcome Measure: Age-specific diarrhea and rotavirus-associated hospitalization rates.

Results: Of 224,160 children younger than 5 years, the diarrhea hospitalization rate was 4.8 in 1000 (n=1086) during the seasonal epidemic. Based on testing of 65% of the hospitalized children, the rotavirus-associated diarrhea hospitalization rate was 1.3 in 1000; the cumulative incidence to 5 years of age was 1 in 160. Rotavirus-associated diarrhea was reported in 37% of the 1001 hospitalized children undergoing testing inside and outside of the census tracts; in children aged 6 to 35 months, this rose to more than 70% during April and May. Ages of children with rotavirus-associated diarrhea were 0 to 2 months (2%), 3 to 5 months (5%), 6 to 23 months (60%), 24 to 35 months (15%), and 36 months or older (19%). Of children aged 0 to 5 and 6 to 11 months, 4 (19%) of 21 and 6 (10%) of 59, respectively, had been born prematurely; 20 (24%) of 83 younger than 1 year were breastfed at the time of illness. Of children younger than 36 months, 77% were cared for in their homes; 13%, in family day care homes; and 8%, in child care centers. The mean (± SD) duration of rotavirus hospitalization based on hospital records and parental questioning was 2.4±1.7 and 3.1±1.6 days, respectively; it was significantly longer (P≤.001) in children with an underlying medical condition. One child required intensive care unit hospitalization. Diarrhea occurred concurrently in 74% of household contacts younger than 3 years; 38%, aged 3 to 18 years; and 29%, older than 18 years. Seventy-six percent of parents were married. Household incomes in Canadian dollars in the 81% reporting were less than $20,000 in 20%, $20,000 to $60,000 in 44%, and greater than $60,000 in 36%. Ethnicity was reported as 53% white, 15% black, 10% Asian, 12% East Indian, and 11% other.

Conclusions: Based on testing of 65% of children with diarrhea, rotavirus resulted in hospitalization in a minimum of 1 in 160 children by 5 years of age during the seasonal outbreak. Had 100% of young children with diarrhea undergone testing, the extrapolated cumulative incidence of rotavirus-associated diarrhea by 5 years of age may have been 1 in 106.


Rotavirus is the most important cause of diarrhea in children in developing countries, causing 125 million infections and 600,000 deaths per year. Although in the developed world the death rate is low at 20 to 40 per year (United States), routine use of a tetravalent rotavirus vaccine had been recommended. It was subsequently removed from use because of the risk of intussusception. Good hygiene practice and oral rehydration programs have not controlled disease, and vaccine efficacy was estimated at 80% for prevention of severe disease. A vaccine program may be cost-effective, depending on the cost of the vaccine. The greater Toronto area/Peel region, Ontario, is the largest urban center in Canada, including 816,585 children and teenagers younger than 18 years. We undertook this prospective study to determine the population-based diarrhea- and rotavirus-associated hospitalization rate. In addition, we sought to describe factors that might be common in hospitalized children, including a history of premature birth, child care center attendance, the...
SUBJECTS AND METHODS

STUDY SITES

Study sites included hospitals with pediatric wards (n = 18) providing all of the care for the population of 816,385 children and teenagers within our study census tracts of 132 postal codes. Eleven (61%) of the hospitals each could accommodate 20 or more children; the remainder, fewer than 10. A 19th hospital in the region occasionally admitted a child but declined participation because of expected closure during the study.

The study was approved by the Human Subjects’ Review committee of the University of Toronto, Toronto, Ontario, and each hospital. Statistics Canada, Toronto, provided the number and ages of children in the study census tracts for the region from the 1996 national census.

TARGET POPULATION

All children with symptoms of acute diarrhea were identified through the health record on admission to hospital from November 1, 1997, through June 30, 1998, to include our winter outbreak period. Diarrhea was defined as the passage of 3 or more liquid or semiliquid stools or a single watery stool per day in a child without diarrhea or hospitalization in the preceding 7 days.

STUDY SET-UP AND MANAGEMENT

Identification of Diarrhea Events

Designated site coordinators identified all diarrhea events and provided the physician’s and child’s names and telephone numbers, dates of birth, hospital admission and discharge, postal code, and whether stool was sent for rotavirus testing. This information was forwarded weekly to the study research nurses. All stool specimens were submitted to the Virology Section of the Department of Laboratory Medicine at The Hospital for Sick Children, Toronto.

Identification and Enrollment of Children With Rotavirus-Associated Diarrhea

All children with stool test results positive for rotavirus were identified by the research nurses who then sought telephone consent from parents and information regarding the child and acute illness. This included the child’s date of birth, sex, history of prematurity and breastfeeding, underlying disease, child care arrangements, illness duration, and use of health care providers and hospitals for this illness. In telephone follow-up at 1 month, information was obtained regarding persistent symptoms, diarrhea in household contacts, and household descriptors including marital status, education level, ethnicity, and income. Children were excluded if their physicians did not authorize parent contact, the parent refused or was not available to provide consent, or the parent was unable to speak English.

Strategies to Maximize Study Compliance

Recruitment at sites was enhanced through provision of educational materials for site staff and parents, stool collection kits and rosters for specimen pick-up, telephone liaison, weekly fax of diarrhea events, biweekly to monthly site visits by research nurses, and a study newsletter. Unannounced visits were made to a random sample of sites by research nurses other than the nurse assigned to the site to confirm the availability of stool containers, information sheets, and knowledge about the study.

Data Management

All diarrhea event forms were entered into a database (Filemaker Pro; Claris Corporation, Santa Clara, Calif) on a personal computer and exported for analysis with the use of SAS statistical software (SAS Institute, Carey, NC). Case report forms for rotavirus-infected children were entered into the mainframe computer.

STATISTICAL ANALYSIS

Continuous measures across groups were analyzed by means of analysis of variance. When 2 groups were being compared, unpaired t tests were used. Categorical variables were compared by means of the χ² method. Multiple logistic regression was used to determine predictors for prolonged hospitalization. For each method, the underlying assumptions were checked to ensure that the assumptions were reasonably valid.

LABORATORY METHODS

Stool specimens were labeled and stored at 40°C until transfer to the laboratory. Specimens were processed within 1 week of collection by means of a commercially available rotavirus enzyme-linked immunosorbent assay (IDEIA; Dako Diagnostics, Mississauga, Ontario) following the manufacturer’s protocol. Positive test results were confirmed by means of electron microscopy in the laboratory of The Hospital for Sick Children. Specimens with indeterminate test results were examined by means of electron microscopy and excluded if no rotavirus was found. Remaining specimens were transferred to storage vials and maintained at −20°C.

RESULTS

IDENTIFICATION OF CHILDREN WITH ROTAVIRUS-ASSOCIATED DIARRHEA

Diarrhea was identified in 1638 hospitalized children, of whom 1001 (61%) had stool specimens submitted for testing. Rotavirus was identified in 372 (37%) of tested specimens. The percentages of children younger than 36 months with rotavirus-associated diarrhea by month, November to June, among those undergoing stool testing, were 25%, 22%, 18%, 51%, 36%, 77%, 71%, and 52%, respectively. In Table 1, characteristics of children with positive and negative test results and those not undergoing testing are provided. Significantly more testing was undertaken in younger hospitalized children aged 0 to 35 months presenting with diarrhea.

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(P < .001) and in those hospitalized more than 1 day (P < .001). Significantly more boys than girls presented with diarrhea (57% boys vs 43% girls; P < .001) but the proportion tested (62% boys vs 60% girls; P = .31) and those with positive test results (36% boys vs 39% girls; P = .42) were similar in boys and girls. The rate of findings positive for rotavirus varied by age, including 15% in children aged 0 to 5 months, 52% in children aged 6 to 23 months, 50% in children aged 24 to 35 months, and 26% in children at least 3 years of age. The mean (± SD) durations of hospitalization for children with positive and negative test results and those not undergoing testing ascertained in health record review by inception hospital staff were 2.43 ± 1.69, 3.60 ± 3.24 (P < .001), and 2.70 ± 2.77, respectively. Of the 67% of hospitalized children for whom there was knowledge of child care center attendance, 10% attended child care centers, including 10% with test results positive for rotavirus, 11% with test results negative for rotavirus, and 10% for those not undergoing testing.

**AGE-SPECIFIC HOSPITALIZATION RATE**

The 18 study hospitals provide care for the 224,160 children aged younger than 5 years within our 132 study postal codes, representing 31% of this age group in Ontario (Statistics Canada, 1996). Of the 13,453 hospitalized children younger than 5 years with an admission diagnosis of diarrhea, 10,864 (81%) resided within these census tracts for a diarrhea hospitalization rate observed during the 8-month study period of 4.8 in 1000 (Table 2). Based on testing of 65% of those younger than 5 years, the rotavirus-associated diarrhea hospitalization rate among children no older than 4 years was 1.3 in 1000 children. The peak rotavirus-associated diarrhea hospitalization rate was 2.3 in 1000 for children aged 12 to 23 months during the 8-month study (Table 2). Extrapolated to 100% testing, this rate among children no older than 4 years is 2.0 in 1000 children; for those aged 12 to 23 months, 3.5 in 1000 (Table 2). Census tract data is not available for calculation of age-specific rates within the first year of life.
**Table 2. Age-Specific Diarrhea Hospitalization**

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Population</th>
<th>Rate per 1000 Children</th>
<th>No. of Children</th>
<th>Rotavirus-Positive Test Result, %</th>
<th>Rate per 1000 Children</th>
<th>% Undergoing Testing</th>
<th>No. of Children</th>
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<tbody>
<tr>
<td>&lt;1</td>
<td>46230</td>
<td>10.8</td>
<td>499</td>
<td>30</td>
<td>2.2</td>
<td>66</td>
<td>102</td>
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<td>287</td>
<td>56</td>
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<td>2</td>
<td>44675</td>
<td>3.4</td>
<td>151</td>
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<td>48</td>
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<td>44265</td>
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<td>1086</td>
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<td>135</td>
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<td>194755</td>
<td>0.12</td>
<td>23</td>
<td>6</td>
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<td>1</td>
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<td>1294</td>
<td>37</td>
<td>0.37</td>
<td>63</td>
<td>306</td>
</tr>
</tbody>
</table>

* A child’s risk for hospitalization for diarrhea by 5 years of age is 1 per 43 (ie, 5 times the annual rate).
† A child’s risk for hospitalization for rotavirus-associated diarrhea is 1 per 106, extrapolated to 100% testing and age and sex adjusted.

**SEASONALITY**

The proportional frequency of rotavirus-associated diarrhea in hospitalized children aged 6 to 36 months is shown by month in the Figure.

**FINDINGS IN CHILDREN WITH ROTAVIRUS-ASSOCIATED DIARRHEA**

Of the 372 children hospitalized with rotavirus diarrhea, 37 (10%) were excluded from telephone interview because of lack of consent, inadequate communication in English, or inability to contact by telephone. Response rates were 327 (98%) of 335 for marital status, 326 (97%) of 335 for education, 324 (97%) of 335 for ethnicity, and 272 (81%) of 335 for household income.

Most hospitalized children (75%) were aged 6 to 35 months. Of the 74 (22%) who had 1 or more underlying medical condition for which they regularly saw a physician or took medicine, most conditions were respiratory tract (38%), dermatologic (8%), cardiac (7%), hematologic (including anemia) (6%), gastrointestinal tract (5%), or organic brain disease (5%). Most young children were cared for in their own or a relative’s home (n=211 [77%]), followed by family day care homes (n=36 [13%]) and child care centers (n=23 [8%]). Children who were younger than 1 year on admission had generally been born at term (n=70 [87%]) and were not receiving breast milk at the time illness occurred (n=63 [76%]).

Most illnesses lasted 4 to 7 days (68%). Respondents reported vomiting in 97% of children and fever in 89%. All but 18 children (94%) received intravenous therapy in hospital. The mean (± SD) length of hospital stay on parental questioning was 3.1 ± 1.6 days; this included emergency evaluations and admission procedures and thus is longer than that reported by inception site staff. Length of stay was longer for children who were regularly seeing a physician for an underlying medical condition (4.1 vs 2.9 days; P<.001) and regularly taking medication (4.1 vs 3.0 days; P=.001) than those who did not. Duration of illness for those who regularly saw a physician for a medical condition and those who did not was the same (6.7 vs 6.4 days; P=.55).

Those who regularly took medication for a health condition compared with those who did not had the same duration of illness (7.0 vs 6.4 days; P=.40). Length of stay did not differ among children cared for by their mother at home (3.3 days), at home with a relative or nanny (3.2 days), in family day care homes (3.1 days), or in a child care center (2.8 days) (P=.42). Length of stay was not related to sex, prematurity, breastfeeding, marital status of the mother, education, household size, ethnicity, or household income. A multiple regression model was developed with length of stay in hospital as the outcome and predictors of prolonged hospitalization, including household marital status, education, ethnicity, size, and income, as well as the child’s prematurity, breastfeeding, underlying illness, child care arrangement, and length of illness. Only...
regularly seeing a physician (P<.001) and duration of illness (P=.004) were associated with length of stay in hospital. One child was admitted to the pediatric intensive care unit for 4 days, and there were no deaths.

**HOUSEHOLD FINDINGS**

Two weeks before or after the patient’s illness, diarrhea occurred in 74% of other household children younger than 3 years. Most patients were children of married mothers (76%), with most respondents reporting some or all of a high school (45%) or university education (45%). Ethnicity was highly diverse, with white families representing 53% and the remainder divided among black (15%), Asian (10%), East Indian (12%), and other groups (10%). Household incomes (in Canadian dollars) of less than $20000 (20%), $20000 to $60000 (44%), or more than $60000 (36%) were reported. In 264 (79%) of households, 1 or more people were employed full-time outside of the home.

**RECOVERY FROM ROTAVIRUS ILLNESS**

Of the 335 enrollees, 327 (98%) were observed for 1 month. The duration of the illness was reported as being 1 to 7 days in 79%, with less than 1% having persistence of diarrhea, vomiting, or fever for more than 2 weeks. At 1 month, 88% of children were considered to have returned to their usual health, 77% had regained their weight, and 11% almost had regained their weight.

Children who were regularly seeing a physician for underlying disease before rotavirus illness were less likely than other children to be described by the respondent as equally as healthy at 1 month before the onset of illness (80% vs 90%; P=.02), as children were routinely taking medication (77% vs 89%; P=.02). Comparison of the patients who were healthy at 1 month with those who were not revealed little difference in mean age (24 vs 26 months; P=.55), proportion of boys (88% vs 88%; P=.92), prematurity (88% vs 89%; P=.86), breastfeeding (95% vs 87%; P=.10), length of hospital stay (3.1 vs 3.7 days; P=.12), or duration of illness (6.4 vs 7.2 days; P=.26).

**FINDINGS IN CHILDREN WITH ROTAVIRUS-ASSOCIATED DIARRHEA YOUNGER THAN 6 MONTHS**

Twenty-one children were confirmed to be younger than 6 months on telephone interview, including 5 (2%) aged 2 months or younger and 16 (5%) aged 3 to 5 months of the 335 children with rotavirus-associated diarrhea. Of these, 11 (52%) were boys and 10 (48%) girls; 4 (19%) had been born before 37 weeks’ gestation; 6 (29%) reported underlying disease (respiratory tract [n=2], cardiovascular [n=1], musculoskeletal [n=1], and other [n=2]) and were regularly seeing a physician for underlying medical problems; and 3 (14%) were regularly taking medications for a medical condition. Twenty (95%) of these children were cared for at home. Thirteen children (62%) had a 4- to 7-day duration of illness; 2 children (10%), 1- to 3-day; 5 children (24%), 8- to 14-day; and 1 child (5%), more than 2 weeks. The mean duration of hospitalization was 3.5 days (SD, 2.4 days). All received intravenous therapy; the mean duration of use was 3.0 days (SD, 1.7 days). Their household profile included 16 (76%) with married and 3 (14%) with common-law parents, 16 (76%) of white ethnicity, and 10 (48%) with a college education. Of the 19 (90%) households reporting their income, 9 (47%) reported an income of $20000 to $60000 and 6 (32%), more than $60000.

Parashar and Glass et al reported hospitalization in 1 of 73 children by 5 years of age among a US birth cohort of 3.9 million, with 50000 rotavirus-associated hospitalizations annually. This was based on discharge diagnoses and also included nosocomial cases. The Institute of Medicine in 1985 had generated an estimated number of hospitalizations approximately half of these at 23000 per year, although this figure was extrapolated from a study of only 126 children. A study using the Vaccine Safety Datalink, which enrolled children from 4 health maintenance organizations, estimated diarrhea-associated hospitalization for 1 in 57 children in the first 5 years of life. Our observed rotavirus-associated diarrhea hospitalization rate of 1776 or 13/10000 children in the 1997-1998 seasonal outbreak, while similar to the crude annual rate of 13.7/10000 children reported after the introduction of a specific International Classification of Diseases, Ninth Revision, Clinical Modification code, is likely an underestimate.

For our hospitalization rates, several points should be considered. First, we studied only the period of seasonal outbreak but noted a fairly swift drop-off at each end of the study period, suggesting that we captured most cases. Our finding of 37% of diarrhea hospitalizations due to rotavirus would not be dissimilar to that of 17% during a single year. Second, we sampled 61% of all hospitalized children, including 68% aged 6 to 24 months and 65% of those younger than 5 years but just 50% of all children with short stays of less than 2 nights or older than 3 years of age. We have systematically underestimated hospitalizations of short duration and those in older children. Third, we have not included children who have received intravenous rehydration for rotavirus-associated diarrhea in our emergency departments. From a sample of hospital emergency departments using intravenous hydration for treatment of children with an inception diagnosis of diarrhea studied during the same period, 20 (44%) of the 45 children from whom stool samples could be obtained for testing (45/360 [13%]) had test results that were positive for rotavirus. The therapeutic strategy of emergency intravenous therapy, where children receive a minimum of 4 hours of hydration rather than hospitalization, has probably increased since the end of the 1992 study period on which published numbers were based. In summary, we have likely underestimated the hospitalization rate, particularly those of short duration.

If it is reasonable to assume that the number of hospitalizations due to rotavirus-associated diarrhea identified in our study captured nearly all such events during the 12-month period, and that the infection experience in our follow-up period was representative of the previous 5 years, then the estimated cumulative incidences of diarrhea and rotavirus-associated diarrhea by 5 years of age, based on 65% testing, is 1/160 (289/46230 [Table 2]). Cor-
fecting for 100% testing and using observed age, sex, and testing rates of our population, the cumulative incidence by 5 years of age is 1 in 106 (434 in 46,230; Table 3). Failure of some children admitted with a diagnosis of diarrhea to undergo testing is inevitable; diarrhea often is diminished substantially by the time a child is admitted for intravenous therapy, usually with restricted oral intake. We did not evaluate discharge diagnoses or include nosocomial disease. Some children not undergoing testing may have had extraintestinal tract causes of their diarrheal illness; their longer hospitalization is noted. In our population, the true cumulative incidence by 5 years of age likely lies between the 1 in 106 had we tested samples from 100% of children and 1 in 160 based on our actual testing of samples from only 65% of children admitted with diarrhea during the seasonal outbreak.

Our study demonstrates that rotavirus infections account for more than one third of admissions for diarrhea and dehydration during the epidemic season, as previously reported (35% to 65%)12 and 17% year round.2 Our epidemic season began in February, well beyond that of the southwestern United States and supporting known progressive temporal and geographic movement across the continent.18 During peak season, rotavirus causes more than 75% of cases in children undergoing testing aged 6 through 36 months.17,18 Studies based on the Hospital Discharge Survey indicated that in the United States, diarrhea of all causes accounts for 9% to 13% of all hospitalizations among children younger than 5 years.2 In our prospective study, even if, among the 39% of children of all ages who did not undergo testing, the proportion of children with test results positive for rotavirus among those hospitalized was zero (an unlikely event), the proportion of children with positive test results among those hospitalized with diarrhea would be 23%. Although most severe disease occurs from 3 through 24 months of age, we found that 34% of hospitalizations occurred after 24 months of age, somewhat higher than the 25% previously reported, reflecting our inclusion of children and teenagers of all ages.2

The finding of a history of prematurity in 13% of those infants presenting with rotavirus in their first year and particularly in 19% of children younger than 6 months is higher than our regional rate of 7% (Aileen Moore, MD, oral communication, May 1999), suggesting an association. Others have related a history of prematurity, birth to severe illness and death.19 The relation of breastfeeding, at least partially, in 24% of young hospitalized children, to the onset of diarrhea supports other observations that this is not providing complete protection.20,21 Although one fifth of the children had underlying disease, most of these were wheezing, repeated ear infections, eczema, iron deficiency anemia, and urinary tract infections rather than the illnesses of a medically fragile population (eg, immunodeficiency). The duration of most illnesses was a maximum of 1 week.22 The mean duration of rotavirus-associated hospitalization, reported by parents at 3.1 days, was similar to published rates of 3.4 days10 but longer than the 2.4 days reported by inception hospital staff, which may, in fact, be more accurate from a health care cost perspective. A longer hospital stay was significantly associated with regularly seeing a physician for a medical condition and regularly taking medication for an underlying condition. A longer duration of illness was found in children regularly taking medication for an underlying condition. The slightly longer duration of hospitalization of children with test results that were negative for rotavirus may reflect other causes of admission due to diarrhea. Although there were 4 fatal rotavirus cases and a fifth case with severe neurologic sequelae resulting from associated dehydration reported at our hospital in a 12-month period in the 1975-1976 period,23 none occurred during this outbreak period, suggesting more effective early management with oral therapy. The absence of deaths and limited pediatric intensive care unit care is not unexpected, given that in the United States, 15 to 20 deaths per year are observed, generally in children with underlying disease or prematurity,24 and our country is approximately one tenth that size. Deaths due to rotavirus have decreased dramatically during the past 30 years in the United States.25 Data from the Institute of Clinical and Evaluative Science on hospitalization for children with discharge diagnoses of gastroenteritis in Ontario during a 10-year period, 1985-1986 through 1994-1995, show a steady decrease in the number of cases and rate of hospitalization (eg, 1986-1987, 12,093 cases; 1994-1995, 8,856 cases).26 This coincided with a major effort to initiate early use of oral rehydration and early refeeding as well as a major reduction in bed availability in many communities.27

Child care centers were used by only 10% to 11% of children in each of the groups not undergoing testing or in whom test results were positive or negative for rotavirus, but for many (33%), this information was not available. From the telephone questionnaire of household members of children with positive test results, only 8% of children younger than 36 months of age were enrolled in child care centers. A review of child care arrangements in Canada for 1996 found that 11% of children aged 0 to 17 months with mothers in the paid labor force at-

### Table 3. Calculation of Extrapolated Number of Children Hospitalized With Rotavirus-Associated Diarrhea*

<table>
<thead>
<tr>
<th>Age, mo</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>628</td>
</tr>
<tr>
<td>6-23</td>
<td>453</td>
</tr>
<tr>
<td>24-35</td>
<td>164(40)</td>
</tr>
<tr>
<td>36-59</td>
<td>121(42)</td>
</tr>
</tbody>
</table>

*The extrapolated number of children from our census tract hospitalized with rotavirus-associated diarrhea, had 100% rather than 65% (Table 2) been tested, equals

\[(166 	imes 0.1415) + (282 	imes 0.5236) + (93 	imes 0.4754) + (87 	imes 0.37) + (125 	imes 0.1487) + (206 	imes 0.5310) + (57 	imes 0.5938) + (65 	imes 0.386) = 434.4 \text{ or } 435 \text{ children.}

If all children younger than 5 years, rather than 65%, had been tested, we would expect to have observed 435 children, rather than 289 (Table 2), with rotavirus-associated diarrhea hospitalizations in the census tract.
Pediatric Rotavirus Epidemiology Study for Immunization (PRESI) Collaborators

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Project Team

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In a telephone survey of more than 600 households of infants and young children in the study census tracts selected through random dialing in the study region in May and June 1998, 14.6% of respondents indicated that their children younger than 6 years attended child care centers. Although child care center attendance has been found to increase the risk of clinic visits for diarrhea due to rotavirus, it does not necessarily increase the risk of hospitalization. We speculate that the ongoing monitoring of attendees' health by child care workers and prompt exclusion of symptomatic children means earlier attention to appropriate rehydration and a reduced risk of hospitalization.

Rotavirus occurred across the full range of household socioeconomic findings of marital status, education, and ethnicity. Nearly 30,000 children are among 100,000 immigrants and refugees legally entering our province and region each year. We had suspected, before the study, that, despite universal health care coverage, there might be an overrepresentation of immigrant children who were not accessing the health care system early enough to avoid dehydration and hospitalization. There is evidence that the health care of immigrants is not necessarily on a par with that of nonimmigrants. The ethnicity profile reported in this hospitalized population suggests slightly more rotavirus hospitalization in nonwhites compared with the region's population, but the populations are not exactly comparable. In the aforementioned random telephone survey of our community in an effort to further characterize our general population, white and Asian subjects represented a somewhat greater proportion at 60% and 12%, respectively, whereas there were fewer black and East Indian subjects at 8% and 7%, respectively; biases related to presence of a household telephone and evening telephone sampling may be present. Although these data are suggestive, we cannot confirm a somewhat higher risk of rotavi-
ruses hospitalizations among black and East Indian subjects, and most hospitalizations did occur in white children. Although the failure of 20% of respondents to provide income data limits somewhat the usefulness of that variable, rotavirus hospitalizations occurred across a broad range of income and educational profiles. In the aforementioned regional telephone survey, 28% failed to provide these data but fewer (11%) reported incomes of less than $20000 and more (46%) reported incomes over $60000, suggesting but not confirming a higher rate of rotavirus hospitalizations among those with the lowest incomes.

CONCLUSIONS

The network of sentinel hospitals has provided us with the opportunity to obtain a longitudinal, population-based hospitalization rate in a cohort of more than 10000 children and complete information on clinical cases.23 We had anticipated that hospitalization would be restricted almost exclusively to children attending child care centers, with underlying medical conditions, with single parents, from households with less education or lower incomes, and from ethnic groups perhaps less familiar with accessing the health care system. We have, however, demonstrated that rotavirus-associated diarrhea is an important cause of hospitalization of all children in our region. Acceptance of a routine rotavirus immunization program when a vaccine becomes available will depend on how an expected reduction in hospitalizations, affecting from 1 in 160 to 1 in 106 children by 5 years of age, as well as expected reduction in other severe and costly outcomes of rotavirus infection, are ranked relative to competing programs.

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