

# Economic analysis of rotavirus-associated diarrhea in the metropolitan Toronto and Peel regions of Ontario

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**OBJECTIVE:** To measure the economic cost of rotavirus-associated diarrhea for a selected group of families, in a nonexperimental setting, and to estimate the factors that influence these costs.

**DESIGN:** Use and other socioeconomic data from a family survey (the Pediatric Rotavirus Epidemiology Study for Immunization) of children who tested positive for rotavirus were collected for the metropolitan Toronto and Peel regions of Ontario during the rotavirus season of 1997-1998. Service costs were estimated from provider data. A statistical regression analysis was used to explain the variances of provincial health care costs, prescription drug costs and indirect (work-loss) costs.

**SETTING:** Data were collected in hospitals, emergency rooms, paediatric practices, primary care clinics and licensed daycare centres. Hospital coverage was wide, but community coverage was not.

**PATIENTS AND OTHER PARTICIPANTS:** Children with diarrhea were tested for rotavirus. Those who tested positive and

whose parents consented for their children to participate were included in the study.

**INTERVENTIONS:** None

**MAIN OUTCOME MEASURES:** The main outcomes were provincial health care costs, drug costs, nonmedical costs and the number of days of work missed by parents per child, as well as factors that determine these costs.

**RESULTS:** Children in the most severe category incurred costs of \$2,663/person, and those in the least severe categories incurred costs of approximately \$350/person. The most important determinant to explain provincial health care costs was the number of health problems that the child had before having rotavirus. Costs due to work loss of parents were considerable for children in all severity groups and were influenced by family working conditions.

**CONCLUSIONS:** When considering the economic implications of rotavirus, prior health status should be considered and indirect costs should be recognized for their importance.

**Key words:** Cost; Cost analysis; Rotavirus

*Résumé à la page suivante*

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## Analyse économique de la diarrhée à rotavirus dans les régions métropolitaines de Toronto et de Peel, en Ontario

**OBJECTIFS :** Évaluer les coûts de la diarrhée à rotavirus dans un groupe sélectionné de familles, en milieu non expérimental, et étudier les facteurs qui influent sur ces coûts.

**PLAN D'ÉTUDE :** Nous avons utilisé, entre autres, les données socio-économiques recueillies dans le cadre d'une enquête menée dans les régions métropolitaines de Toronto et de Peel, en Ontario, au cours de la saison 1997-1998, auprès de familles ayant des enfants dont les résultats d'examens ont confirmé la présence de rotavirus (*Pediatric Rotavirus Epidemiology Study for Immunization*). Les coûts des services ont été évalués à partir de données provenant de fournisseurs. Nous avons procédé à une analyse de régression statistique pour expliquer les variances de coûts liés à la prestation de soins, à l'achat de médicaments et à des facteurs indirects (absentéisme).

**MILIEU :** Les données ont été recueillies dans des hôpitaux, des salles d'urgence, des cabinets de pédiatrie, des cliniques de soins primaires et des garderies autorisées. Le champ d'observation dans les hôpitaux était étendu, mais pas celui dans la collectivité.

**PATIENTS ET AUTRES PARTICIPANTS :** Les enfants souffrant de diarrhée ont subi des tests pour savoir s'ils étaient porteurs de rotavirus. Ceux pour lesquels les résultats ont été positifs et dont les parents ont accepté de participer à l'étude ont été sélectionnés.

**INTERVENTION :** Aucune

**MESURES DES PRINCIPAUX PARAMÈTRES :** Les principaux paramètres étaient les coûts liés aux soins de santé, aux médicaments, aux services ou aux produits non médicaux et le nombre de jours de travail manqués par les parents, par enfant, ainsi que les facteurs déterminants de ces coûts.

**RÉSULTATS :** Les enfants les plus gravement malades ont occasionné des coûts de 2 663 \$/personne et les enfants les moins malades, de 350 \$/personne. Le facteur déterminant le plus important pour expliquer les coûts soins de santé était le nombre de problèmes de santé que les enfants présentaient avant de devenir porteurs du rotavirus. Quant aux coûts liés à l'absentéisme des parents, ils atteignaient des sommes considérables, peu importe le degré de gravité, et ces coûts variaient en fonction des conditions familiales de travail.

**CONCLUSION :** Les deux points importants à considérer dans le fardeau économique des maladies à rotavirus sont l'état de santé des enfants avant d'en devenir porteurs et les coûts indirects.

Rotavirus is the major virus that causes severe gastroenteritis in young children (1). Gastroenteritis, a common and seasonal disease, includes symptoms of diarrhea and vomiting. If body fluid loss is significant, the child can experience a loss of electrolytes, leading to dehydration. Children with severe cases of gastroenteritis are usually hospitalized so that intravenous or oral rehydration can be provided. There is a significant disease burden as a result of gastroenteritis. In the United States, it is estimated that 30,000 hospitalizations occurred due to rotavirus in 1995. Twenty to forty deaths occur annually due to rotavirus (2).

The economic burden of diarrhea with a rotavirus etiology in children was addressed in two studies. Using experimental data from large, randomized clinical trials, Griffiths et al (3) in the United States and Tukala et al (4) in Finland identified high hospitalization costs and productivity losses due to rotavirus-related gastroenteritis in children. At present, there are no comparable estimates of rotavirus events in Canada. Very little is known about the factors that influence the cost of rotavirus-associated diarrhea.

Because rotavirus-associated diarrhea is usually more severe than diarrhea with other etiologies, cost data on this topic, specifically, must be obtained when considering the role of a future rotavirus vaccine program. Furthermore, although researchers have presented descriptive analyses of rotavirus costs, they have not identified predictive factors, such as prior health status, duration of illness and family work conditions, which may explain these costs. Finally, researchers (3,4) have studied the economic burden of rotavirus in experimental contexts, but not under actual practice conditions.

In the 1997-1998 epidemic season, the Pediatric Rotavirus Epidemiology Study for Immunization (PRESI) study group in the Toronto and Peel regions undertook a large-scale hospital and more limited-scale outpatient and

community survey of the extent of rotavirus in the metropolitan Toronto and Peel regions of Ontario. An economic survey was conducted for those who tested positive for rotavirus. In the present paper, the results of the economic survey are reported with the objective of measuring the economic (societal) costs of rotavirus-induced diarrhea under actual practice conditions, and the factors that influence these costs are also reported.

### DATA AND METHODS

From November 1997 through June 1998, 49 sites in the Toronto and Peel metropolitan area were surveyed (5,6). These included 18 hospitals, eight emergency care rooms, 19 daycare centres and four paediatric practices. Other than the hospitals (which were fully surveyed), the nonhospital sites formed a nonrepresentative sample. All children at the 49 sites who had symptoms of diarrhea were identified (n=2524). Stool samples were collected and tested with a commercial IDEIA rotavirus test (Dako Diagnostics, Canada) and were confirmed by electron microscopy. If the children tested positive for rotavirus, their physicians and parents were asked to participate in the present survey, and, if they agreed, a telephone survey (socioeconomic questionnaire) was conducted at the time of diagnosis and at one-month follow-up.

In the survey, data on utilization were collected for a number of types of services and categories of costs. A standard cost was developed for each service (Appendix I). The services and costs were aggregated into five categories: provincial health services (inpatient and outpatient hospital and physician services); prescription drugs (including rehydration fluids); other supplies (including nonprescription drugs, diapers and clothes); transport costs (including taxis, parking, public transport and a mileage allowance for those taking their own cars); and time lost from work. Per

person costs were derived for each of the categories reported. The sample was classified into four groups that represented levels of severity, as approximated by health care utilization (7). These were: child was admitted to hospital; child was seen in the emergency room (but was not subsequently hospitalized); child visited a doctor (but not in emergency room or hospital); and child was not seen in any of the above formal health care settings. For each of the four categories, data were gathered on the number of persons who incurred costs as well as on descriptive statistics for those costs.

Regression equations were developed to explain the determinants of three groups of services – provincial health care costs, those drug costs that were eligible for private health insurance in at least some plans (ie, excluding over-the-counter medications), and the indirect costs of the loss of work. Regression equations were not developed for the other categories (transport and nondrug supplies) because of the lack of appropriate explanatory indicators in the survey for these variables.

In the regression equation for provincial health care costs, the following variables, commonly used in the utilization literature, were included: the age of the child, the child's previous health status (measured by the number of previously identified medical problems), the duration of symptoms, and binary variables that summarized membership in one of three severity groups – severe (hospitalization), moderate (emergency room treatment) and mild rotavirus (physicians' offices or no formal treatment). The severity indicator of the two lowest severity groups was collapsed into a single group because of the small number of children in those groups. With regard to the binary variables, the mild group was omitted for the purpose of the regression equations, and the other two groups were, therefore, analyzed with reference to the mild group.

Regression models were developed for prescription drug utilization, but because prescription drug costs represent a small and less important aspect of costs associated with rotavirus, these results are summarized only briefly.

Days off work due to child illness, multiplied by the average daily Ontario wage, was the measure of lost income. Not all families who had at least one working member lost income. Using data from those families with at least one working parent, a binary logistic equation was developed. The dependent variable was a binary variable indicating whether the family had any reported lost income. Independent variables were: age of child, duration of illness, parental living arrangements (living alone=0, living with partner=1), numerical education level of parent, income class (categorized income level) of parent, number of working parents, and how the child was cared for when the parent worked (in-home=0, out-of-home=1). For those working families who did lose income, a linear regression equation was developed to explain the amount of income lost (time lost from work multiplied by the average daily Ontario wage). This variable was a descriptor of lost time, because the value of a lost day of work is assumed to be the

**TABLE 1**  
**Characteristics of individual rotavirus patients in sample of study participants**

Characteristic	Occurrence (%)
Number of completed interviews	421
Number of interviews with missing data	6
Number of parents refusing interviews or unable to respond	37
Total number contacted	464
Age of patient	
Younger than six months	28 (6.7)
6–23 months	261 (62.0)
24–35 months	61 (14.5)
36 months or older	71 (16.9)
Mean value (Standard deviation)	23.21 (20.43) months
Previous health status	
No identified medical problems	328 (77.9)
Number with one medical problem	75 (17.8)
Number with two medical problems	12 (2.9)
Missing	6 (1.4)
Duration of illness	
Fewer than five days	102 (24.2)
5–9 days	273 (64.8)
10–14 days	42 (10.0)
More than 14 days	4 (1.0)
Mean value (standard deviation)	6.40 (3.51) days
Level of care received	
Hospitalized	343 (81.5)
Emergency room	33 (7.8)
Primary physician care	35 (8.3)
No formal care	10 (2.4)

same for everyone, and it therefore abstracts from occupational differences. The independent variables in this equation were the same as those that were used in the logistic regression.

## RESULTS

### Description of the sample

A total of 1638 children were admitted to hospital. Of those, 1001 (61%) were tested, and 372 (37%) of those tested positive for rotavirus. In outpatient settings, 886 children had diarrhea, of whom 397 (45%) were tested. Of these, 92 children (23%) tested positive for rotavirus. In total, 464 parents of children with rotavirus were contacted and were asked to respond to the socioeconomic questionnaire. Thirty-seven were excluded because of a lack of consent, inadequate communication in English or the authors' inability to contact them by telephone. Four-hundred twenty-seven agreed to reply to the questionnaire. Six of those had missing data, and, therefore, 421 responses were usable.

Age distribution and other characteristics of the children and their families are shown in Table 1. The majority

**TABLE 2**  
**Basic cost data by level of care (severity group) from an economic analysis of rotavirus-associated diarrhea in the metropolitan Toronto and Peel regions of Ontario**

Cost category	Number for whom costs were more than 0 (% of total)	Mean value of costs (\$)	Standard deviation (\$)	Median (\$)
<b>Child was hospitalized (n=343)</b>				
Direct costs	343 (100.0)	2,261	1,525	1,824
Provincial health care costs	343 (100.0)	2,125	1,492	1,704
Inpatient hospital care	343 (100.0)	1,943	1,491	1,527
Emergency room care	325 (94.8)	173	72	129
Clinic and physician office care	181 (52.8)	33	17	25
Other direct costs (out-of-pocket)	343 (100.0)	136	96	114
Prescription drugs and rehydration fluids	218 (63.6)	27	29	20
Other services	314 (91.5)	39	31	30
Transport	335 (97.7)	85	81	62
Indirect costs	254 (74.1)	579	526	516
Total of all categories	343 (100.0)	2,690	1,650	2,290
<b>Child was seen in emergency room, but was not hospitalized (n=33)</b>				
Direct costs	33 (100.0)	320	120	307
Provincial health care costs	33 (100.0)	214	71	179
Emergency room care	33 (100.0)	168	60	129
Clinic and physician office care	27 (81.8)	56	31	50
Other direct costs (out-of-pocket)	33 (100.0)	106	80	83
Prescription drugs and rehydration fluids	28 (84.8)	31	21	29
Other services	33 (100.0)	45	60	26
Transport	31 (93.9)	37	28	35
Indirect costs	24 (72.7)	672	1,170	452
Total of all categories	33 (100.0)	809	1,063	675
<b>Child was seen in physician's office (n=35)</b>				
Direct costs	35 (100.0)	116	50	116
Provincial health care costs	35 (100.0)	66	32	50
Clinic and physician office care	35 (100.0)	66	32	50
Other direct costs (out-of-pocket)	35 (100.0)	50	33	45
Prescription drugs and rehydration fluids	17 (48.6)	24	19	21
Other services	34 (97.1)	31	21	22
Transport	30 (85.7)	9	7	6
Indirect costs	26 (74.3)	377	186	258
Total of all categories	35 (100.0)	396	240	398
<b>Child was not seen in a formal health care setting (n=10)</b>				
Direct costs	10 (100.0)	20	17	18
Other direct costs (out-of-pocket)	8 (80.0)	25	16	25
Prescription drugs and rehydration fluids	5 (50.0)	8	2	8
Other services	7 (70.0)	21	12	17
Transport	2 (20.0)	6	7	6
Indirect costs	8 (80.0)	387	207	387
Total of all categories	9 (90.0)	366	230	387

*n* Number

**TABLE 3**  
**Results of regression analysis in an economic analysis of rotavirus-associated diarrhea in the metropolitan Toronto and Peel regions of Ontario**

Dependent variable	Provincial health care costs: coefficient (standard error)	Lost income, no=0 and yes=1: coefficient (standard error)	Amount of lost income if losses are less than 0: coefficient (standard error)
Number of observations	405	297	248
Constant term	-229.27 (251.46)	0.294 (1.009)	227.03 (218.19)
Age of child	-7.87* (3.12)	0.019 (0.012)	-0.58 (1.79)
Number of previous illnesses	494.90** (131.34)		
Duration of illness	60.82** (18.18)	0.030 (0.047)	23.22* (10.33)
Hospitalization or not (hospitalization=1, primary or no formal care=0)	1989.44** (230.43)		
Emergency room (without hospitalization) or not (emergency room care=1, primary or no formal care=0)	215.76 (315.55)		
Parental living arrangements (alone=0, with partner=1)		-0.421 (0.700)	103.37 (135.42)
Education level of parent		-0.037 (0.147)	28.38 (34.70)
Income level of parent		-0.020 (0.063)	-11.91 (14.65)
Number of working parents		1.043** (0.322)	68.12 (53.07)
Care of child when parent working (in home=0, out of home=1)		-0.897* (0.421)	-113.99 (82.27)
R <sup>2</sup>	0.293	0.105	0.040

Significance levels \*0.01–0.05; \*\*0–0.01; R<sup>2</sup> measure of goodness of fit

of the children (62%) were between the ages of six and 23 months. Seventy-eight per cent of the children had no previous serious medical problems; however, 75 (18%) had one previous medical problem. The most common medical problems were respiratory (42% of all problems), dermatological (12% of all problems) and cardiovascular (8% of all problems). Two-thirds of the illnesses lasted from five to nine days, and approximately one quarter lasted fewer than five days. Most (343, 82%) of the children in the sample were hospitalized (ie, were in the 'severe illness' category).

#### Measurement of cost per person

The overall mean cost per family was \$2,301 (SD±\$1,731). The mean value for provincially funded health care services (mainly hospital care, emergency room care and physician services) was \$1,796 (SD±\$1,551). The remainder of

total costs were either indirect costs from work loss (mean value of \$565 [SD±\$579]) or other costs, including nonprescription drugs, other supplies and transport (mean value of \$124 [SD±\$95]).

In Table 2, the costs of each service or cost item by severity group are reported. In the case of hospitalized patients, hospital costs were the major expense. In all other categories, indirect costs were the major cost category.

#### Analysis of provincial costs

The results of the regression equation, in which the dependent variable was provincial cost per person, are reported in Table 3. These results indicate that a previous health problem was statistically significant, increasing average costs by \$495 for each additional previous condition. Other variables that were statistically significant were age

**TABLE 4**  
**Values of variables in the lost income equations for respondent**

Variable description	Value (%)
Parental living arrangements	
Living with partner	338 (80.3)
Not living with partner	72 (17.7)
Missing data	11 (2.6)
Education of answering parent	
Did not complete high school	56 (13.3)
Completed high school	119 (28.3)
Attended school beyond high school	236 (56.1)
Missing data	10 (2.4)
Income class of household	
Less than \$20,000	65 (15.4)
\$20,000–\$49,000	114 (27.1)
\$50,000–\$99,999	113 (26.8)
More than \$100,000	46 (10.9)
Missing data	83 (19.7)
Number of working persons in household	
Zero	45 (10.7)
One	135 (32.1)
Two	199 (47.3)
More than two	34 (8.1)
Missing data	8 (1.9)
Care of child while parent working	
At home with parent	243 (57.7)
Out of home (eg, with relative, child care)	178 (42.3)

(each month of age was associated with a decrease in cost of \$8), duration of illness (\$61 per additional day of illness), and hospitalization (\$1,989 more than low severity costs if the patient was hospitalized). Being seen in the emergency room did not significantly affect provincial costs compared with the low severity group.

#### Analysis of drug costs

Significant factors in the equation that determine whether persons used prescription drugs were age (negatively related), number of previous illnesses (positively related) and duration of illness (positively related). For those who obtained some prescription drugs (n=260), age of child (negatively related) and duration of illness (positively related) were related significantly to drug expenses.

#### Analysis of indirect costs

Most (80%) of the parents lived with a partner, and 56% attended school beyond high school (Table 4). Only 15% of households earned less than \$20,000 per year; there were two working persons in 47% of the households. In 58% of the sample, the parent at home normally cared for the children.

The regression equation that explained income loss was run on data from 297 families – those with at least one reported working member (hence, who could potentially lose income). The variables that were related significantly to whether income was lost were the number of working parents and where the child was cared for while the parent was working. Families with two working members were almost two times more likely to report an income loss than families with one working parent. Parents were 60% less likely to report an income loss when the children were normally cared for in the home.

A total of 248 family members who were working actually reported having taken some days off work. The results of the regression equation explaining lost income (Table 3) indicate that only the duration of illness was related significantly to the amount of income loss (an increase of illness by one day results in an increase lost income of \$23).

### DISCUSSION AND CONCLUSIONS

For the families in the sample, hospitalization, emergency room, transport and indirect costs were the most frequently incurred costs. Societal costs for children treated in hospital were \$2,690 per child, and costs for cases treated in the emergency room (but not hospitalized) were \$809. When considering the indirect costs of work loss, rotavirus costs were considerable even for those families where care was sought only in a doctor's office or not at all. Most of the costs for families with children in the low severity category were due to work loss. The equation explaining provincial health expenditures performed quite well overall. The work-loss equation indicated that circumstances of the family were key contributors toward explaining the probability of work loss. Illness severity was the key determinant of how much time was lost from work.

A key finding from the regression analysis of provincial health care costs was that a child's previous health status was a statistically significant indicator of health care utilization and was of a considerable magnitude. An analysis of subgroups revealed that the previous health status variable was associated positively with hospitalization, and for those who were hospitalized, this variable was associated with higher provincial costs. For those who were not hospitalized, previous health status was not a significant determinant of provincial costs.

It should be pointed out that the sample in the PRESI study was not representative of the entire population with rotavirus. While PRESI achieved wide coverage in the hospital survey, it did not achieve anywhere near complete coverage from the other sites. It is likely that the hospital sample captured more severe cases than the entire group of hospitalized rotavirus cases – not all hospitalized cases were tested for rotavirus, and those who were tested had longer stays (5) and were likely to be more severely ill. The nonhospital sample also contained a considerable number of nonsampled cases. There is no evidence to assess whether nontested cases were of lower severity than those who were tested (6). The sensitivity

and specificity of the test are other potential reasons why less serious cases may be missed, and hence, positively tested cases might be more severe than true positive cases. However, the sensitivity of the IDEIA test was 100% and specificity was 99.2% compared with electron microscopy; therefore, this additional possibility is unlikely to be a factor that results in higher severity cases being included (8).

It should also be emphasized that the PRESI results were based on self-reported data, and its accuracy needs to be verified. We were able to verify that the events of hospital-

ization were reported accurately; however, the length of stay was self-reported at 3.1 days and was reported by the study nurses at 2.4 days. Therefore, total hospital costs, which were based on days of care, could be over-estimated by 29%. Other costs were based on events, and there was no method to validate those costs.

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**APPENDIX I**  
**Sources of cost data**

Resource item	Measure of output	Method used to measure cost
Inpatient hospitalization (ward)	Days of care, including attending physician's service	Hospital component: Per diem Resource Intensive Weight for Case Mix Group 294 (Gastroenteritis, under age 70) of 0.2023 (9) applied to cost per weighted case for each study hospital (10). Physician components based on Ontario Schedule of Benefits (11), admission assessment (code C264, \$32.55) and daily visit (code C262, 7.10)
Inpatient hospitalization – paediatric intensive care	Days of care	Estimated paediatric intensive care unit cost per day from study hospital (\$1,200)
Emergency room visit	Visit, including fee for emergency room attending physician	Mean value of emergency room cost and intravenous fluids, including allocated costs from diagnostic centres, for three study hospitals (\$91 per visit). Ontario physician fees for emergency room partial consultation (\$38) (11, code A414)
Physician office visits	Visits	Fee per visit for paediatric consultation (Ontario Schedule of Benefits, code A263, \$49.85) and general practitioner (11, code A007, \$24.80)
Prescription medications – antibiotics and other	Prescription, by number of days drug taken at home	Antibiotics: a standard cost based on the Ontario Drug Benefits plan (12) for amoxicillin (125 mg, three times daily) (\$2.10 per seven days) plus dispensing fee (\$11 flat rate). Drugs other than antibiotics: actual cost as reported in questionnaire
Oral rehydration fluids, over-the-counter medications, other supplies		Cost as self-reported
Other services, such as diapers, toys, clothes, supplies, diaper creams, baby wipes, vaseline, laundry		Costs as self-reported
Transportation	Out-of-pocket expenses (public transport, taxi, parking, accommodation) and kilometres travelled for medical care and supplies	Self-reported outlays and travel at 23¢/km
Lost work	Days	Average daily earnings in Ontario, July 1998 (\$129 per day) (13)

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