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Costs of gastroenteritis in The Netherlands

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SUMMARY

In order to target the most important cost components of gastroenteritis in The Netherlands and to indicate which change of policy yields the largest decrease in costs, the cost of illness of gastroenteritis and the number of Disability Adjusted Life Years (DALYs) in the Dutch population in 1999 were determined. The costs of gastroenteritis were estimated using data mainly from a community-based cohort study. For calculating DALYs, data on the number of deaths due to gastroenteritis were used from Statistics Netherlands. On average, the costs for gastroenteritis were 77 Euro (€) per case. For all patients in The Netherlands, the costs were estimated at €345 million (ranging between €252 and €531 million). Indirect costs made up 82% of this total. An estimate of costs for patients with campylobacter, salmonella or norovirus infections was, in total, 10–17% of the costs of gastroenteritis. Gastroenteritis was associated with a loss of approximately 67 000 DALYs.

INTRODUCTION

In The Netherlands, with a population of 16 million inhabitants, approximately 4·5 million episodes of gastroenteritis occur every year [1]. Gastroenteritis is usually self-limiting and in general does not lead to high costs for an individual. However, due to the high annual number of individuals affected, the total costs can be substantial [2–4]. Estimates of the costs can be used to provide information on the burden of the disease, to compare the costs of different public health interventions, to target the most important cost components and to indicate which change of policy yields the largest decrease in costs [5]. In The Netherlands, the total costs of gastroenteritis have not been estimated previously.

The objective of this study was to determine the costs of gastroenteritis in The Netherlands in 1999, according to the bottom-up method (in which cost data of specific age groups are determined and costs are aggregated over groups to calculate the total costs). In addition to the costs of gastroenteritis in general, we also estimated the respective costs for gastroenteritis due to the top three of foodborne pathogens: campylobacter, salmonella and norovirus. Furthermore, an estimate was made of the number of Disability Adjusted Life Years (DALYs) in the Dutch population, in order to provide insight into the public health burden of gastroenteritis and to compare this with the burden of other diseases. The DALYs combine the effect of morbidity and mortality and has

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been adopted as a basis for Dutch public health policy [6].

METHODS

Data sources

To calculate the cost of illness from the societal perspective, we needed data on the total number of cases of gastroenteritis per age group, the volumes for use of resources such as medication, health services and the indirect costs, and the actual economic costs of each of these items. With this, the average costs per case in a certain age group could be calculated and subsequently multiplied by the total number of cases in each age group in The Netherlands. Then, the total absolute costs of gastroenteritis could be calculated by summing costs over all age groups. To calculate DALYs, we needed age-specific data on the number of deaths of gastroenteritis patients, duration and severity of symptoms and the disability weight for gastroenteritis in The Netherlands. We needed the information per age group, because of differences in incidence and type of costs (e.g. absence from work) between age groups.

Results from a community-based prospective cohort study (CB study) on gastroenteritis were used to calculate the incidence and the absolute number of gastroenteritis patients per age group. This study was performed in The Netherlands in 1999, in cooperation with the sentinel general practice (GP) network of The Netherlands Institute for Health Services Research (NIVEL) [1]. This network consists of approximately 44 practices that cover 1% of the Dutch population, representative regarding age, gender, regional distribution, and degree of urbanization. In short, the cohort consisted of two consecutive, age-stratified samples of individuals registered at GPs in this network. Twenty-seven GPs participated in the first cohort and 31 in the second. Persons were invited by mail, and after 3 weeks, a reminder was sent to non-respondents. At the start of the follow-up, all participants in the cohort completed a baseline questionnaire. Cases with gastroenteritis identified in the cohorts during the 6 months of follow-up were requested to submit stool samples, complete a questionnaire on risk factors, and complete a medical diary for 4 weeks. In retrospect, a research nurse checked whether a reported GP visit was actually due to gastroenteritis. Consultations for other complaints were not counted. In the medical diary, cases reported daily about specific gastrointestinal symptoms, bed rest, absence from work or school (of the patient or someone taking care of the patient), use of medication, and use of the health-care system (GP, outpatient department, hospital, alternative treatment). It was clearly stated that only medical care use, absence, or bed rest due to their gastroenteritis episode should be reported. All gastroenteritis cases from the CB study who completed the medical diary were included in the analyses for this study. Gastroenteritis was defined as: three or more loose stools in 24 h, or three or more times vomiting in 24 h, or diarrhoea with at least two additional symptoms, or vomiting with at least two additional symptoms. Additional symptoms could be abdominal pain, abdominal cramps, nausea, blood in stool, mucus in stool, fever, diarrhoea or vomiting.

Since all stool samples in the CB study were tested for enteropathogens, with the test results available to GPs, the frequency of requesting stool tests by the GP could not be determined in this study. However, in 2001, GPs of the sentinel network of NIVEL completed a questionnaire whenever they ordered laboratory diagnostics for a gastroenteritis patient. They also reported all consulting cases. These data were used to estimate the order frequency of a GP for laboratory diagnostics. The age groups on the NIVEL questionnaire were just slightly different (e.g. 10–19 years instead of 12–17 years) from the categories of the CB study and were therefore used as proxies for our age groups.

To examine whether the number of cases admitted to a hospital, a rather rare event, in the CB study differed from the number expected, we used data from the National Medical Register (NMR) in The Netherlands. This registry collects data on hospital discharge diagnoses from all hospitalized patients in The Netherlands, including information on duration of stay. Hospitalizations with a primary or any of the secondary diagnoses coded with ICD-9 codes 001-009 and 558 (codes related to gastroenteritis) [7, 8] for 1999 were obtained for analyses. The costs for only hospital admissions with primary diagnosis gastroenteritis were calculated separately.

Costs

Costs were divided into direct medical costs, including medication (both over-the-counter and prescriptions), GP costs, outpatient department costs, hospital inpatient costs, and laboratory tests, direct non-medical

costs (transport costs) and indirect non-medical costs (productivity losses, costs of informal care). All costs were calculated per age group (age groups: <1, 1–4, 5–11, 12–17, 18–64 and 65+ years) and were measured in Dutch guilders, but were converted to Euros (€) for this study (1 NLG = €0.45, as of 1 January 2002).

Direct medical costs

Whenever a patient reported taking medication prescribed by a doctor, a surcharge for the pharmacy was added to the price of the medication. Drugs included antibiotics, oral rehydration solutions (ORS), painkillers, anti-diarrhoeic medication and other prescribed drugs. Full details and dosage were unknown. Therefore the guidelines for average daily dosages from the Dutch pharmaco-therapeutical precept were used. For antibiotics the average tariffs for macrolides were used. The national average costs for different types of drugs were taken from this precept [9]. Non-specified over-the-counter medication was disregarded in the cost calculations.

Each consultation with a GP or specialist in an outpatient department and admission to a hospital generated consultation fees and transport to and from the practice or hospital. Guidelines for average costs of the above components to be used in pharmaco-economic research, as issued by the Dutch National Health Insurance Board, were used in the cost calculation [10].

A consultation with a specialist in alternative treatment generated only consultation fees. For a homeopath this was €50, for an acupuncturist this was €40.60 per consultation (guidelines from the Dutch Association of Classic Homeopaths and the Dutch Acupuncture Association).

The average costs of laboratory faeces tests for a range of enteric pathogens were taken from the guidelines of the National Health Tariffs Authority.

Direct non-medical costs

The average distance from a Dutch household to their GP was estimated to be 1·8 km [10]. We further assumed (because of lack of data) that half of the patients used a car for transport, while the other half used a bicycle. The average distance from a Dutch household to the nearest general hospital was estimated to be 7·0 km [10]. We assumed that all patients used a car to go to the hospital. We disregarded transportation by taxi or other public transport and parking fees. The average costs per kilometre by car, were used in the cost calculation [10].

Transport costs to and from the practice for alternative treatment were not calculated since no data were available on the average distance to such practices. These costs are likely to be only a very small proportion of total costs and including them would not significantly change the total cost estimate. Other transport costs, e.g. transport to a pharmacy, were not calculated. Direct out-of-pocket expenses (such as the purchase of cleaning materials and replacements for items spoilt as a result of the illness) were not taken into consideration due to lack of reliable data.

Table 1. *Cost vectors in The Netherlands, 1999 (in €)*

	Costs (€)
Direct medical costs	
Prescription charges	5·26
GP visit	16·59
Alternative treatment	40·60–50
Outpatient department visit	40·84
Hospital admission (per day)	235·97
Stool test*	58·20
Direct non-medical costs	
Transport – private transport by car (per km)	0·11
Indirect costs	
Average costs of absence from work (per day)	120·06
Average costs of informal care (per day)	112·43

* Assuming that in general one stool sample is tested for campylobacter, yersinia, salmonella and shigella.

Indirect costs

Productivity losses were calculated for cases over 18 years old, using the friction cost method. In the Dutch guidelines for cost research [10], age and sex are taken into consideration, but no distinction is made by type of occupation or education. Time lost from school was estimated. However, in the absence of proper cost estimates for this, no societal costs were placed upon it. For productivity losses due to informal care we also used the friction cost method. Age and sex of the carer could not be taken into account due to lack of data. We therefore used the average costs for a person between 30 and 49 years old.

All cost vectors that were used in the cost estimate are given in Table 1.

Sensitivity analyses

A sensitivity analysis was conducted to consider uncertainty in the calculated total number of gastroenteritis cases in The Netherlands and to consider variation in cost components that contributed most to the total costs. Using the 95% confidence interval (CI) of the standardized incidences of gastroenteritis per age group, a minimum and maximum number of cases per age group were calculated. Furthermore, for those cost components that contributed most, 95% CIs of their point estimates were calculated. With these CIs, the minimum and maximum of the costs could be calculated.

Costs for specific pathogens causing gastroenteritis

In addition to the costs of gastroenteritis in general, we also estimated the respective costs for gastroenteritis due to the top three foodborne pathogens: campylobacter, salmonella and norovirus [1]. The costs of norovirus could be directly estimated from the data of the CB study, using the same method as for gastroenteritis in total. The number of patients with campylobacter and salmonella were too small in the study (9 and 3 respectively) to use this direct method without risking a great uncertainty in the results. Therefore, the costs for campylobacter and salmonella (and norovirus) were estimated using an indirect method: cases from the CB study were divided into those using the health-care system (GP, outpatient department, alternative treatment and/or hospital) (consulting patient) and those not using the health-care system (non-consulting patient). For both groups, again the total costs for all cases were estimated per age group by the previously described direct method. From 1996 to 1999, in The Netherlands, the incidence of gastroenteritis in GPs and the role of a broad range of pathogens were studied (GP study) [11, 12]. We used the results from this study to estimate for *consulting patients* the proportion that was due to campylobacter and salmonella by age group. These proportions were then used to calculate the total costs for all consulting cases with symptoms that could be attributed to campylobacter and salmonella by age group. The costs for *non-consulting patients* with a campylobacter or salmonella infection were calculated as follows. From the patients from the CB study who did not consult their GP and did not visit another health-care system, the overall proportion of patients with campylobacter and salmonella was estimated. Then using the age distribution of the campylobacter ($n=89$) and salmonella cases ($n=33$) in the GP study, the proportion of gastroenteritis patients, with campylobacter and salmonella, not consulting a health-care worker was estimated per age group [12]. These proportions were then used to calculate the total costs for all non-consulting patients that could be attributed to campylobacter and salmonella by age group. The total costs for patients with campylobacter and salmonella were calculated by summing the costs of consulting and non-consulting cases. For norovirus, results from the indirect and direct method could be compared, to provide insight in the dependence of results by the used method.

DALYs

The number of DALYs associated with gastroenteritis was calculated as follows. We obtained data on number of deaths with a primary cause of death coded as ICD-9 codes 001-009 and 558 and on the average age at time of death for 1999 from Statistics Netherlands [13]. To calculate the number of Years of Life Lost (YLL) in 1999, the remaining statistical life expectancy at the time of death was calculated from survival tables from 2000 [14] and aggregated over all deceased patients with gastroenteritis. The number of Years Lived with Disability (YLD) was calculated as follows. Data from the CB study were used to calculate the total number of gastroenteritis cases per age group and the average duration of their disease episode for 1999. The disease weights were taken from a Dutch national study on the burden of diseases [6]. This study aimed at determination of the disease weight for a large array of diseases, and within diseases, for different stages of severity of disease. For infectious diseases, the study resulted in severity weights for a year that includes an episode of gastroenteritis. Both weights for mild and more severe gastroenteritis were determined. A disease weight of 0·005 (95% CI 0·001–0·009) was being attributed to a year including a period of mild gastroenteritis (duration up to 2 weeks), a disease weight of 0·03 (95% CI 0·018–0·039) was being attributed to a year including a period with a more severe course of gastroenteritis (duration 2–4 weeks). These disease weights were multiplied by the estimated total number of cases with a short or a longer course of gastroenteritis in The Netherlands. The two figures for YLD were added. The total number of DALYs related to gastroenteritis was calculated by summing the number of YLL and YLD of patients with gastroenteritis in 1999.

RESULTS

Gastroenteritis cases and duration of illness

Of the 4860 participants in the cohort, 1052 case episodes were observed: 720 persons had one episode of gastroenteritis, 129 had two, 18 had three and 5 had four. This yielded an overall standardized incidence of gastroenteritis (standardized for age, gender and cohort) of 283/1000 person-years, with an estimated total of 4·5 million cases per year (Table 4). The incidence was the highest in children between 1 and 4 years and <1 year old (900/1000 and 740/1000 person-years respectively).

Of these cases, 774 (74%) participated in the case-control component, which was found to be largely representative of all observed cases in the cohort [1]. Of these, 646 (83%) completed a medical diary. The medical diary was completed relatively more often for children (89% of 0–4 years old, completion by a parent) than for cases in older age groups (70% of cases older than 18 years). Sixty-three of the 646 patients (10%) had no complaints of diarrhoea, but they did have complaints of vomiting.

Duration of illness was on average 12 days (median 8 days, range 1–101 days). The cases in the oldest age group (65 years and older) suffered the longest (median 22 days, range 1–56 days) and the 18–64 years group suffered the shortest (median 3 days, range 1–28 days). In total, 296 cases (46%) were confined to bed for an average of 2·6 days (median 2 days, range 1–14 days).

Direct medical costs

Forty-two cases (7%) used antibiotics, 48 (7%) used ORS, 28 (4%) used anti-diarrhoeic medication, 218 (34%) used painkillers, 40 (6%) used other prescribed medication and 31 cases (5%) used other medication without a prescription from a GP. Patients 12–17 years old, and patients older than 65 years used relatively more medication. In total, 65 GP-confirmed consultations were reported (standardized consultation rate of 5%). Young children were seen relatively more often by their GP. For one baby a homeopath was consulted, and one person 69 years old visited an acupuncturist five times because of his gastroenteritis complaints. A specialist in an outpatient department (a paediatrician) was consulted three times (0·5% of 646). One baby visited a paediatrician and was admitted to the hospital 1 day later, where he stayed for 2 days. Furthermore, another baby was admitted to the hospital for 10 days. One elderly person (72 years old) went to the emergency room and was admitted to the hospital where he remained for 10 days (Table 2).

According to the NMR of hospital discharge diagnoses in The Netherlands, 17978 patients with gastroenteritis as primary or secondary diagnosis were admitted to the hospital in 1999. Of these, 14, 22, 5, 2, 30 and 27% were for individuals aged <1, 1–4, 5–11, 12–17, 18–64 and 65+ years. The median number of days admitted to the hospital was 5 days. In total approximately 4/1000 patients (0·4%) with gastroenteritis were hospitalized in The Netherlands. In the CB study, 0·5% of the cases were admitted to the hospital (3/646) (Tables 2 and 3). Of the total hospitalizations, 12669 (70%) had gastroenteritis as their primary diagnosis (Tables 3 and 4), corresponding with a hospitalization rate of 0·3% of all community cases.

In 2001, the GPs from the sentinel network reported 1306 consultations for gastroenteritis, by age group. For these 1306 consultations, 177 (14%) patients' stool samples were sent to a laboratory for testing on enteropathogens. Relatively more stool samples were taken from adult cases; for 21% of patients older than 65 years a stool sample was taken. Seventy per cent of all stool samples were taken from patients older than 19 years (Table 2).

In total, direct medical costs were approximately €61000 (Table 4), with an estimated average of €14 per case using the hospital data from the CB study. Average costs were highest for those 65 years or older (Table 3). Calculating the costs for hospital admissions based on the data from the NMR, the total average costs amounted to €13 per person. However, the costs were distributed differently over the age groups. Average costs were still highest for those 65 years or older (Table 3). The costs due to hospital admissions contributed most to the direct medical costs (Tables 3 and 4).

Direct non-medical costs

Transport costs were relatively small; for all cases with gastroenteritis in The Netherlands seeking medical care they amounted to €80000, with a negligible average per case (Tables 3 and 4).

Indirect costs

In total 146 cases (23%) in the CB study reported absence from school (including day-care centres)

Table 2. *Use of resources, per age group (%)*

	Age (years)						
	<1 (*n*=184)	1–4 (*n*=253)	5–11 (*n*=119)	12–17 (*n*=15)	18–64 (*n*=51)	65+ (*n*=24)	Total (*n*=646)
Associated with direct medical costs							
Total medication	38	25	16	53	33	54	29
GP visit	17	9	6	7	2	8	5*
Alternative treatment	0·5	0	0	0	0	21	0·9
Outpatient department visit	0·5	0·8	0	0	0	0	0·5
Hospital admission CB	1·1	0	0	0	0	4	0·5
Hospital admission NMR†	2	0·6	0·1	0·2	0·2	1	0·4
Stool tests (% of all cases)‡	1·2	0·9	0·5	0·5	0·3	2	0·6
Stool tests (% of GP patients)‡	8	10	8	8	17	21	14
Associated with direct non-medical costs							
Transport§	18	10	6	7	2	13	11
Associated with indirect costs							
Absence from work	0	0	0	0	14	0	1·1
Absence of other person for informal care	14	12	18	7	6	0	13

* Standardized for age and cohort.

† Based on data from the National Medical Registry, 1999 (total of registered hospitalizations at NMR divided by total estimated number of cases per age group). Number of admissions by age group (median duration of stay): <1 year, 2581 (5 days); 1–4 years, 3979 (4 days); 5–11 years, 891 (4 days); 12–17 years, 339 (4 days); 18–64 years, 5403 (5 days); 65+ years, 4785 (11 days).

‡ Based on the questionnaires completed by GPs from the sentinel network, 2001.

§ Transport to GP (€0.40 per visit), outpatient department and hospital (€1.54 per visit).

or work due to illness. Of these, 65 were younger than 5 years, 71 were children going to school, 3 were adults going to school and only 7 were adults with jobs. These adults were absent from work for an average of 5 days (range 2–10 days). Eighty-two cases (13%), of which 79 were children, reported absence from work by a carer in the same household. This was on average for 2 days (range 1–12 days) (Table 2).

Indirect costs were in total €284 million. Despite a small proportion of cases being absent from work (1%), the costs for absence from work were higher than costs for informal care, because of the high number of cases between 18 and 64 years old and the higher costs per day (Table 4). The average costs were €63.5 per case, 82% of the total average costs per case (using the hospital data from the CB study) (Table 3).

Total costs

On average, the total costs per case were €77. Individuals 18 years and older had relatively higher costs per person, with the highest costs being for cases over 65 years (€114 per case). Children aged between 1 and 11 years had relatively low costs per case (Table 3). Using the costs for hospital admissions based on data from the NMR, the highest costs per case were found in cases between 18 and 64 years old (Table 3).

For the 4·5 million case episodes in the Dutch population in 1999, the societal costs were estimated at €345 million (Table 4). Using the data from the NMR did not significantly change this estimate.

Sensitivity analyses

Confidence intervals were calculated per age group for the incidence rate, the number of GP consultations, the number of hospital admissions, the number of days absent from work and the number of days of informal care. With these CIs, the minimum and maximum of the total number of cases and of related costs for these cost vectors were estimated per age group. Varying the incidence rates led to a range in the total costs of €249–439 million. Of the four major cost components, varying the number of hospital admissions had the greatest impact on the total costs,

Table 3. *Average costs (in €) per case in a prospective population-based cohort study in The Netherlands, December 1998 to December 1999, by age group*

Items contributing to costs (€)	Age (years)						
	<1 (*n*=184)	1–4 (*n*=253)	5–11 (*n*=119)	12–17 (*n*=15)	18–64 (*n*=51)	65+ (*n*=24)	Total (*n*=646)
Medication	2·0	1·2	0·8	2·3	2·0	4·6	1·9
GP visit	2·8	1·5	1·0	1·1	0·3	1·4	0·8
Alternative treatment	0·3	0	0	0	0	8·5	0·8
Outpatient department visit	0·2	0·3	0	0	0	0	0·1
Hospital admission CB	15·4	0	0	0	0	98·3	9·6
Hospital admission NMR*	27·2	6·1	1·5	2·9	4·6	46·6	8·9
Stool tests	0·7	0·5	0·3	0·3	0·2	1·0	0·4
Direct medical sub-total†	21·4	3·5	2·1	3·7	2·5	113·7	13·5
Direct medical sub-total‡	33·2	9·6	3·6	6·6	7·1	62·1	12·9
Transport costs	0·1	0	0	0	0	0·1	0·0
Direct non-medical sub-total	0·1	0	0	0	0	0·1	0·0
Absence by case	0	0	0	0	84·9	0	45·1
Absence of other person for informal care	31·2	27·1	33·1	89·9	8·8	0	18·3
Indirect sub-total	31·2	27·1	33·1	89·9	93·7	0	63·5
Total†	52·6	30·7	35·1	93·7	96·2	113·8	77·0
Total‡	64·5	36·8	36·7	96·6	100·8	62·1	76·4

* Based on data from the National Medical Registry, 1999. Patients with both a primary or secondary diagnosis. Total costs for patients with only gastroenteritis as a primary diagnosis were estimated at €71.9 per case.
† Including costs from hospital admissions based on data from the CB study.
‡ Including costs from hospital admissions based on data from the National Medical Registry, 1999.

leading to a range of €327–436 million. Varying all four cost vectors at the same time, led to a range in the total costs of €252 million (if all four minimum estimates were taken) to €531 million (for the maximum estimates) (Table 5).

Costs for specific pathogens causing gastroenteritis

Using the direct method, the costs of norovirus infections were estimated to be 6% of the total costs of gastroenteritis. In order to calculate the costs of campylobacter, salmonella and norovirus using the indirect method, the costs for cases from the CB study were divided into costs for cases using the health-care system [in total €62 million (18%), average €148 per case] and costs for cases not using the health-care system [in total €281 million (81%), average €70 per case]. Eighty-five per cent of the costs for cases using the health-care system were direct medical costs. In 10% of the cases in the GP study a campylobacter infection was detected, in 4% a salmonella infection and in 5% a norovirus infection [1]. Taking the age distribution into account, the total costs for consulting cases with a campylobacter, salmonella and norovirus infection were €4.8, €2.8 and €2.1 million respectively. Of the cases in the CB study who did not consult the health-care system, 1·4, 0·5 and 17·4% had a campylobacter, salmonella and norovirus infection, leading to the total costs of these patients of €4.4, €1.3 and €44.0 million respectively. The total costs of campylobacter, salmonella and norovirus infections (both consulting and non-consulting) were €9, €4 and €46 million; 3, 1 and 13% of the total costs respectively. Using the costs of norovirus estimated with the direct method and the costs of campylobacter and salmonella estimated with the indirect method, the costs of these three pathogens combined were 10% of the total costs of gastroenteritis (Table 6).

DALYs

In 1999, 241 persons died of gastroenteritis, with relatively the highest percentage in cases 65 years and older (51 deaths/100 000 persons). As a result of this premature death, 2563 years of life were lost.

Table 4. *Estimated costs (× €1000) for The Netherlands of gastroenteritis, by age group*

	Age (years)						
	<1	1–4	5–11	12–17	18–64	65+	Total
Incidence rate (per 1000 person-years)*	740	900	481	157	234	194	283
Estimated total number of cases	147 799	698 802	663 629	173 750	2 379 018	413 401	4 476 399
Medication	296	841	528	401	4 733	1 889	8 687
GP visit	413	1 054	648	192	774	572	3 653
Alternative treatment	40	0	0	0	0	3 497	3 537
Outpatient department visit	33	226	0	0	0	0	258
Hospital admission CB	2 274	0	0	0	0	40 645	42 920
Hospital admission NMR†	4 025	4 270	1 027	508	10 849	19 277	39 956
Stool tests	105	347	188	53	454	418	1 565
Direct medical sub-total‡	3 162	2 469	1 363	646	5 961	47 020	60 620
Direct medical sub-total§	4 913	6 738	2 390	1 154	16 810	25 652	57 657
Transport costs	9	17	8	2	10	34	81
Direct non-medical sub-total	9	17	8	2	10	34	81
Absence by case	0	0	0	0	201 971	0	201 971
Absence of other person for informal care	4 606	18 943	21 945	15 628	20 978	0	82 100
Indirect sub-total	4 606	18 943	21 945	15 628	222 949	0	284 070
Total‡	7 777	21 429	23 316	16 276	228 919	47 055	344 771
Total§	9 527	25 699	24 343	16 784	239 769	25 686	341 808

* Standardized for age, gender and cohort. Standardized for the Dutch population, 1999.
† Based on data from the National Medical Registry, 1999. Both patients with a primary or secondary diagnosis. Total costs for patients with only gastroenteritis as a primary diagnosis were estimated at €20 million.
‡ Including costs from hospital admissions based on data from the CB study.
§ Including costs from hospital admissions based on data from the National Medical Registry, 1999.

Table 5. *Estimated ranges of the total costs (× €1000) for The Netherlands of gastroenteritis, by age group*

	5th percentile	95th percentile
Varying the incidence rate*	249 223	439 448
Varying the cost vectors		
GP consultations	342 494	352 182
Hospital admissions	326 789	435 909
Absence from work	302 482	376 960
Informal care	314 350	400 088
Varying all four cost vectors	251 802	530 825

* 95% CI of incidence per 1000 person-years: <1 year, 606–875; 1–4 years, 766–1034; 5–11 years, 389–575; 12–17 years, 95–219; 18–64 years, 169–298; 65+ years, 126–262.

In the CB study, duration of illness was known for 619 persons. A total of 387 (63%) cases had complaints less than 2 weeks (on average 5·2 days) and for 232 (37%) cases the complaints lasted longer than 2 weeks (on average 23·7 days). The number of YLD for the cases with mild gastroenteritis were 13 993 (0·005 × 63% of the estimated total number of cases), for the cases with more severe gastroenteritis 50 332 (0·03 × 37% of the estimated total number of cases). The total number of YLD was therefore 64 326 (95% CI 32 998–90 620). The total number of DALYs was thus 66 889 (95% CI 35 561–93 183).

DISCUSSION

In this study, the average costs per patient with gastroenteritis were €77. The total costs of patients with gastroenteritis in The Netherlands were estimated at €345 million in 1999. The combined costs of campylobacter, salmonella and norovirus were approximately 10–17% of the total costs of gastroenteritis. In 1999, gastroenteritis was associated with a loss of approximately 67 000 DALYs.

Even with relatively low costs per case (€77), the total costs are high because of a high incidence of gastroenteritis in The Netherlands (283/1000 person-years). Varying this incidence per age group resulted in a range of the costs of €249–439 million. However, this range should probably be smaller, since it is unlikely that the incidences are either all in the highest

Table 6. *Estimated costs (× €1000) for The Netherlands for specific pathogens causing gastroenteritis, by age group*

	Costs	% of total costs for gastroenteritis (€344 771)
Direct method		
Norovirus	19 579	6
Direct costs*	4 192	1
Indirect costs	15 386	4
Indirect method		
Patients using the health-care system	62 147	18
Direct costs*	53 023	15
Indirect costs	9 124	3
Patients not using the health-care system	280 921	81
Direct costs*	6 070	2
Indirect costs	274 851	80
Campylobacter	9 209	3
Salmonella	4 044	1
Norovirus	46 059	13

* Including transport costs.

or all in the lowest percentiles for all age groups at the same time. A variation in the major four cost components also lead to substantial variation in the costs. For example, the costs for hospital admissions range between €25 000 and €134 000 in total.

We consider the costs (and DALYs) estimate a minimum because of several reasons. In our study we did not measure any cases with complicated gastroenteritis, leading to haemolytic uraemic syndrome, Guillain–Barré syndrome, sepsis, or arthritis. Neither costs of hospitalizations and deaths, nor costs of treatment and long-term health consequences for these relatively expensive conditions are included in our calculations. Also, we disregarded several cost vectors, such as non-specified over-the-counter medication, direct out-of-pocket expenses, taxi use and parking fees, although we believe that the effect of these aspects on the total would be limited. In order to quantify the costs of informal care more precisely more information on carers should be obtained in further studies (e.g. who was the carer, and what was his/her work).

This is the first cost-of-illness study of gastroenteritis in The Netherlands. There have been studies in other countries, but mainly focusing on only foodborne illness [3, 4, 15, 16], on gastrointestinal diseases including non-infectious and chronic diseases [17, 18], or on specific pathogens [19–22]. Therefore, their results are difficult to compare with ours. A recent study in England (the IID study), similar to ours, estimated the total costs of gastroenteritis at €1039 million [2]. When the number of inhabitants of England is taken into account, these costs are almost equal to ours: about €22 per inhabitant.

The use of ICD codes in mortality statistics and hospital discharge diagnoses has some limitations, because the ICD codes are not very specific. Most hospitalizations and deaths were found for the rather non-specific code 558 (other non-infectious gastroenteritis and colitis). Exclusion of this ICD code would produce a fall in the number of hospitalizations from 17 978 to 5906, the number of deaths from 241 to 40 and the number of DALYs from 67 000 to 65 000. This code (558), however, strongly correlates with, for example, the incidence of laboratory-confirmed rotavirus [8]. To obtain more reliable estimates of the true number of hospitalizations due to gastroenteritis, specific hospital studies into the use of ICD codes are needed.

For the estimates of the costs for specific pathogens it was assumed that within the groups of cases consulting and not consulting the health-care system, patients have the same costs, regardless of their aetiology. However, for example, duration of illness is on average longer in patients with a campylobacter infection when compared to patients with a norovirus infection [23]. Therefore, costs of absence from work and informal care are probably higher for patients with a campylobacter infection. Also duration of hospital admission might vary between pathogens. This might explain the difference in the costs of norovirus infection calculated with the direct and the indirect method. The costs calculated with the indirect method are probably too high for cases with a norovirus infection and too low for cases with campylobacter and/or salmonella infection. Consequently, the pathogen-specific costs should be considered as rough estimates. Although often regarded as a mild disease, the costs of a norovirus infection are substantial (€20 million, calculated with the direct method), mainly due to absence from work by a carer (79% of the total costs).

The number of DALYs calculated by us (67 000), indicates that the public health burden of gastroenteritis is substantial. In the Dutch Public Health Status and Forecasts (PHSF), published in 1997, the number of DALYs for a large number of diseases

and disorders were estimated [24]. The number of DALYs calculated by us for gastroenteritis is in the same order as the number of DALYs associated with dementia, heart failure, colon cancer and traffic accidents. In the PHSF of 1997, the number of DALYs of gastroenteritis was estimated at 6900. This difference was because the incidence used was only based on patients consulting their GP. In a study by Havelaar et al. [25] the mean health burden of campylobacter-associated illness in the Dutch population in the period 1990–1995 was estimated at 1400 DALYs (90% CI 900–2000). Campylobacteriosis is the cause of gastroenteritis in 2% of all gastroenteritis cases [1]. If the health burden would be proportionally subdivided among the related pathogens, the health burden of campylobacteriosis according to our study would yield a similar estimate, i.e. 1287 DALYs (95% CI 660–1812). However, of the estimated DALYs in the Havelaar et al. study, 38% are for complications such as Guillain–Barré syndrome and arthritis, which we did not include in our estimates.

The number of DALYs was highly dependent on the YLD. However, in general with common diseases, the YLD is strongly influenced by the weight factors used for the mild and more severe illness. Changing this factor slightly (e.g. from 0·005 to 0·01) causes a substantial change in the total YLD (from 64 000 to 78 000), because of the high absolute number of cases. Consequently, the usefulness and validity of DALYs for common, short-term and relatively mild infectious diseases such as gastroenteritis should be evaluated thoroughly.

In conclusion, in 1999, gastroenteritis was associated with considerable costs to society and loss of DALYs in The Netherlands. Because of increasing trends in consultations for gastroenteritis in GPs since 2000 [26], as well as in salmonellosis and campylobacteriosis in recent years, it is anticipated that current costs are even higher.

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REFERENCES

1. Wit MAS de, Koopmans MPG, Kortbeek LM, et al. Sensor, a population-based cohort study on gastroenteritis in the Netherlands, incidence and etiology. Am J Epidemiol 2001; **154**: 666–674.
2. Roberts JA, Cumberland P, Sockett PN, et al. The study of infectious intestinal disease in England: socio-economic impact. Epidemiol Infect 2003; **130**: 1–11.
3. Buzby JC, Roberts T. Economic costs and trade impacts of microbial foodborne illness. World Health Statist Quart 1997; **50**: 57–66.
4. Scott WG, Scott HM, Lake RJ, Baker MG. Economic cost to New Zealand of foodborne infectious disease. NZ Med J 2000; **113**: 281–284.
5. Koopmanschap MA. Cost-of-illness studies. Useful for health policy? Pharmacoeconomics 1998; **14**: 143–148.
6. Maas PJ van der, Kramers PGN, eds. The Dutch Public Health Status and Forecasts Report 1997. Weighted health and life expectancy [in Dutch]. Bilthoven/Utrecht: National Institute of Public Health and the Environment/Elsevier/de tijdstroom, 1997.
7. World Health Organization (WHO). International classification of diseases, 9th revision. Geneva: WHO, 1977.
8. Wit MAS de, Koopmans MPG, Blij JF van der, Duynhoven YTHP van. Hospital admissions for rotavirus infection in the Netherlands. Clin Infect Dis 2000; **31**: 698–704.
9. Loenen AC van, ed. Pharmaco-therapeutical precept [in Dutch]. Amstelveen: College voor zorgverzekeringen, 2002.
10. Oostenbrink JB, Koopmanschap MA, Rutten FFH. Guidelines for cost research. Methods and guideline prices for economic evaluations in health care [in Dutch]. Amstelveen: College voor zorgverzekeringen, 2000.
11. Wit MAS de, Koopmans MPG, Kortbeek LM, Leeuwen WJ van, Bartelds AIM, Duynhoven YTHP van. Gastroenteritis in sentinel general practices, the Netherlands. Emerg Infect Dis 2001; **1**: 82–91.
12. Wit MAS de, Kortbeek LM, Koopmans MPG, et al. Comparison of gastroenteritis cases in a general practice based-study and a community-based study. Epidemiol Infect 2001; **127**: 389–397.
13. Statistics Netherlands. Primary causes of death. (http://statline.cbs.nl), accessed September 2002.
14. Statistics Netherlands. Life expectancies prognoses 2002. (http://statline.cbs.nl), accessed September 2002.
15. Todd ECD. Preliminary estimates of costs of foodborne disease in the United States. J Food Prot 1989; **52**: 595–601.
16. Withington SG, Chambers ST. The cost of campylobacteriosis in New Zealand in 1995. NZ Med J 1997; **110**: 222–224.
17. Beck IT. Disproportion of economic impact, research achievements and research support in digestive diseases in Canada. Clin Invest Med 2001; **24**: 12–36.
18. Sandler RS, Everhart JE, Donowitz M, et al. The burden of selected digestive diseases in the United States. Gastroenterology 2002; **122**: 1500–1511.

19. Powell M, Ebel E, Schlosser W. Considering uncertainty in comparing the burden of illness due to foodborne microbial pathogens. Int J Food Microbiol 2001; **69**: 209–215.
20. Frühwirth M, Berger K, Ehlken B, Moll-Schüler I, Brösl S, Mutz I. Economic impact of community- and nosocomially acquired rotavirus gastroenteritis in Austria. Pediatr Infect Dis J 2001; **20**: 184–188.
21. Morales RA, McDowell RM. Economic consequences of *Salmonella enterica* serovar enteriditis infection in humans and the U.S. egg industry. In: Saeed AM, ed. *Salmonella enterica* serovar enteriditis in humans and animals. Epidemiology, pathogenesis and control. Ames: Iowa State University Press, 1999: 271–290.
22. Pelt W van, Giessen AW van de, Leeuwen WJ van, et al. Origin, extent and costs of human salmonellosis. Part 2: estimate of the extent of human salmonellosis in the Netherlands and the related economic costs [in Dutch]. Infectieziekten Bulletin 2000; **11**: 4–8.
23. Chin J, ed. Control of communicable diseases manual, 17th edn. Washington: American Public Health Association, 2000.
24. Ruwaard D, Kramers PGN, eds. The Dutch Public Health Status and Forecasts Report 1997. Overview [in Dutch]. Bilthoven/Utrecht: National Institute of Public Health and the Environment/Elsevier/de tijdstroom, 1997.
25. Havelaar AH, Wit MAS de, Koningsveld R van, Kempen E van. Health burden in the Netherlands due to infection with thermophylic Campylobacter spp. Epidemiol Infect 2000; **125**: 505–522.
26. Bartelds AIM. Continuous morbidity registration sentinel network the Netherlands, 2001. NIVEL, Utrecht, 2002.