



National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Disease burden of food-related pathogens in the Netherlands, 2014

RIVM Letter report 2017-0061
M. Bouwknecht et al.



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Colophon

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Synopsis

Disease burden of food-related pathogens in the Netherlands, 2014

The Ministry of VWS has requested RIVM to present an annual update on the number of illnesses caused by 14 enteric pathogens. These pathogens can be transmitted by food, the environment, animals and humans. The number of persons who are ill and who die from the infections is expressed in DALYs (Disability Adjusted Life Years), a measure of the disease burden in the population. Furthermore, the *cost-of-illness* (COI) related to the 14 food-related pathogens were estimated and expressed in euros. The total disease burden caused by the 14 pathogens decreased from around 13,000 DALY in 2013 to 12,600 DALY in 2014. The share of foodborne transmission in this estimated burden was comparable to 2013, mounting to 5,900 DALY in 2014. Therewith, the burden estimates for 2013 and 2014 ranked as lowest estimates since 2009, the first year of the burden estimates. The food-related COI decreased by 7 M€ compared to 2013, reaching a total of 165 M€ for 2014. The increase in burden, yet decrease in costs in the estimates is possibly related to the significant decrease in incidence of rotavirus infections, which display a relatively high cost-per case due to productivity losses.

The research presented in this report results in more insight in the true incidence of foodborne diseases and the associated disease burden and costs-of-illnesses and enables to monitor trend in time for these public health indicators.

Keywords: food-related disease, disease burden, DALY, cost, trend

Publiekssamenvatting

Ziektelast van via voedsel overdraagbare ziekteverwekkers in Nederland in 2014

Het RIVM onderzoekt jaarlijks hoeveel mensen ziek worden van 14 ziekteverwekkers die via voedsel in het menselijk lichaam terechtkomen (darmpathogenen). Deze ziektebelasting wordt uitgedrukt in DALY's (Disability Adjusted Life Year), een internationaal gehanteerde maat voor het aantal gezonde levensjaren die verloren gaan aan ziekte of overlijden. Het aantal verloren DALY's als gevolg van de 14 ziekteverwekkers is in 2014 geschat op 5900, en is daarmee vergelijkbaar met de schatting voor 2013 (5.800 DALY's).

Daarnaast wordt geschat welke kosten hieraan verbonden zijn (*cost of illness*). Deze omvatten directe medische kosten, maar ook de kosten van patiënt en/of zijn familie, zoals reiskosten, en de kosten binnen andere sectoren, bijvoorbeeld door werkverzuim. De gerelateerde kosten van de 14 ziekteverwekkers die mensen via voedsel opliepen daalde met 4% van 172 miljoen euro in 2013 naar 165 miljoen euro in 2014.

De onderzochte ziekteverwekkers kunnen niet alleen via voedsel aan de mens worden overgedragen (circa 40 procent), maar ook via het milieu (bijvoorbeeld via oppervlaktewater), dieren, en van mens op mens. De verhouding verschilt per ziekteverwekker. De totale ziektebelasting van alle 'routes' daalde van ongeveer 13.000 DALY in 2013 naar 12.600 DALY in 2014. De totale kosten werden geschat op 379 miljoen euro en waren daarmee lager dan voorgaande jaren. Een belangrijke oorzaak hiervan is een halvering van aantal rotainfecties ten opzichte van 2013.

VWS is opdrachtgever van dit onderzoek. De resultaten bieden handvatten om meer zicht te krijgen op het daadwerkelijke aantal voedselinfecties dat mensen jaarlijks oplopen en de bijbehorende ziektebelasting.

Kernwoorden: voedsel-gerelateerde ziekte, ziektebelasting, DALY, kosten, trend

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1 Introduction

Since 2008, RIVM regularly publishes estimates of the incidence, disease burden and costs-of-illnesses of food-related disease on its web pages in publicly available reports [1-5]. Furthermore the website <https://www.volksgezondheidenzorg.info/> launched in 2014, combines multiple information sources in a single website. The estimates from 2013 onwards will be integrated in this website as of 2016.

The epidemiological estimates of the disease burden are expressed in Disability Adjusted Life Years (DALY). The methodology for these estimates is described in detail in a peer-reviewed paper [1]. The economic burden estimates, the cost-of-illness (COI) expressed in euros, were finalized for all 14 food-related pathogens for the year 2011 [6]. In the current report, trend information from surveillance, demographic information and consumer price index (a measure for changes in price levels of consumer goods and services) was used to update the information to the year 2014.

2 Methods

2.1 Trend information

Data on the size and age distribution of the Dutch population, as well as mortality risks and the number of live births and stillbirths were obtained from Statistics Netherlands¹.

Trend information on the incidence of gastro-enteritis (GE) by pathogen in the general population and consulting the general practitioner was obtained from the following sources:

- Thermophilic *Campylobacter* spp.: RIVM laboratory surveillance
- Non-typhoidal *Salmonella* spp.: RIVM laboratory surveillance
- Norovirus: hospitalisation for viral gastro-enteritis (ICD code 86)
- Rotavirus: RIVM laboratory surveillance,
- Hepatitis A, and perinatal and acquired listeriosis: RIVM-OSIRIS, mandatory notification and active surveillance.
- *Cryptosporidium* spp.: a stable incidence since 2003 was assumed, based on laboratory surveillance data from 2001 to 2007.
- *Giardia* spp.: a continuing decrease with the rate of -1.03% per year observed between 2001 and 2007 was assumed
- No trend information was available for the GE toxin-producing bacteria (*Bacillus cereus*, *Clostridium perfringens* and *Staphylococcus aureus*), hepatitis-E, toxoplasmosis and gastroenteritis due to Shiga-toxin producing *Escherichia coli* O157 (STEC O157)). For the latter, trends in reported fatalities are included.

Trends in hospitalizations for gastro-enteritis as primary cause (ICD codes 20-93; 558.9) were obtained from the National Medical Register up until 2010. From 2011 onwards these data were obtained from Dutch Hospital Data (DHD). Estimates for the number of hospitalized patients were obtained by extrapolation, using the 10-year relationship of the number of hospitalized patients and time series from the laboratory surveillance (primarily tested faeces, but in part (<18 years) rotavirus). Using this method on data for earlier years showed similar estimates for the number and age-distribution of hospitalized GE-patients.

Data on norovirus surveillance was based on ICD9 codes until 2012, and based on ICD10 codes from 2012 onwards. This led to an increased incidence rate per 100,000 of 27.1 compared to 19.7 for 2012 and 37.6 compared to 18.6 for 2013. The baseline incidence rate (i.e., for 1999) was based on ICD9-codes, so straightforward inclusion of the new incidence rates in the update would likely lead to a trend break in methodology used. However, with ICD10 codes, GE cases are expected to be better distinguished and reported, and thus to lead to a more accurate incidence estimate. Yet, for comparison of trends in annual foodborne DALY estimates with earlier years a comparable methodology is needed. Therefore, we used the ICD9 and ICD10 estimates for 2012

¹ <http://statline.cbs.nl/statweb/>, accessed January 28th 2016

and 2013 to estimate the proportional increase due to the new reporting system. Based on ICD9 3293 (2012) and 3132 (2013) cases were reported, based on ICD10 4534 (2012) and 6328 (2013). The proportional increase thus mounted to $(3293+3132)/(4534+6328)=1.69$. The incidence rate for 2014 was subsequently divided by this number.

Excess mortality risks from campylobacteriosis and salmonellosis were assumed constant across the years. Fatalities due to listeriosis and STEC O157 were obtained from active surveillance. Age-specific case fatality ratios for norovirus and rotavirus, originally obtained from German surveillance data, and for protozoan pathogens, originally obtained from the international literature, were assumed constant throughout the years (changes in *years of life lost* therefore reflect changes in incidence on which mortality is based).

2.2 Model updates

The model was not changed since the 2013-update.

2.3 Disease burden

The method for DALY calculations was not changed compared to previous years.

2.4 Cost of illness

Cost-of-illness calculations were not changed compared to previous years (i.e. 2012 and 2011), only the cost prices used for the different resources had to be updated to 2014 euros using consumer price indexes as provided by Statistics Netherlands². In order to allow comparison with earlier results we also updated the earlier cost-of-illness estimates (i.e., 2011, 2012 and 2013) to 2014 euros; hence all differences in the results for the year 2014 compared to earlier years will reflect the impact of trends in the underlying information on demographics and pathogen incidence.

²

<http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71311NED&D1=0&D2=0&D3=142,155,168,181,194,219,232,245,258&HDR=T&STB=G1,G2&VW=T>, accessed January 26th, 2016

3 Results

3.1 Trend information

Trend information for specific pathogens is presented in Table 3. A summary of trends (in comparison with 2013) is discussed below:

- The incidence of **campylobacteriosis** (laboratory confirmed cases) **decreased from** 48.0 to 47.5 cases per 100,000 inhabitants, showing a continuously decreasing trend since 2011 (with an incidence of 51.3 per 100,000 population in 2011)
- The incidence of **salmonellosis** (laboratory confirmed cases) **remained similar** to 2013 with 9.2 per 100,000 inhabitants. The reported incidence rate for 2013 and 2014 were the lowest since 1999 (21.1 per 100,000; the former lowest reported incidence rate was 11.6 per 100,000 in 2009).
- The incidence of gastroenteritis by **rotavirus** (laboratory confirmed cases) **decreased markedly by nearly 60%** from 23.3 to 9.6 cases per 100,000 inhabitants, reaching the lowest level in the period 1999-2014. The former lowest incidence estimate stemmed from 2004, with 15.4 per 100,000.
- The incidence of hospitalizations for viral gastroenteritis (a proxy for the **incidence of gastroenteritis by norovirus**) **decreased** from 37.6 to 31.1 cases per 100,000 inhabitants. Note that the estimated incidence based on hospitalizations for viral gastroenteritis increased markedly from 19.7 and 18.6 in 2012 and 2013, respectively, to 27.1 (2012) and 37.6 (2013), due to the altered registration system (using ICD10-codes instead of ICD9).
- The incidence of **acquired listeriosis** (active surveillance) **increased** from 76 cases in 2013 to 92 cases in 2014. There were **9 recorded fatalities**, similar to the 8 and 7 fatalities in 2012 and 2013, respectively. The statistical life expectancy of fatal cases was 13.6 years; in the DALY model half of this life expectancy is used for calculating years of life lost to correct for comorbidity. Including new data from 2013, the probability of developing **meningitis** as a consequence of acquired listeriosis was updated from 25% to **24%** (95% confidence interval 20-28%).
- The incidence of **perinatal listeriosis** (active surveillance) was 4 cases with 2 fatalities. The number of perinatal cases and mortality were **similar to previous years**.
- The incidence of diseases caused by **STEC O157** (active surveillance) was 79 with 31 hospitalizations (of 71 cases for which this information is known). The number of STEC O157 cases, including the number of hospitalized cases, was **similar to the previous two years**, but higher than the years before. There were no fatal cases recorded. The incidence of HUS cases was 3 in 2014, being lower than the 7 cases in 2013, but comparable to the years before that.
- The incidence of **hepatitis A** (notified cases) **decreased** compared to the previous three years; the incidence was the lowest among the recorded incidences for the years 2006-2014.

The number of **hospitalizations**, likewise **decreased**, with the proportion of hospitalized patients being 22% (compared to 27.5% in 2013).

- The number of recorded hospitalizations for gastroenteritis decreased by about 2,000 to 21,345 in 2014.

3.2 Disease incidence

The incidence of gastroenteritis by pathogen, of disease by non-gastrointestinal pathogens and of sequelae by pathogen in 2014 is presented in Tables 4-7, and Figure 1. Overall there were no marked increases in incidence compared to 2013, with relatively slight decreases in incidence for *Salmonella* spp. and *Campylobacter* spp. and stable similar incidences for the other pathogens except for the increase in acquired listeriosis. The estimated total number of foodborne cases due to the 14 pathogens decreased by approximately 180,000 to 1,500,000 in 2014 compared to 2013. The total number of deaths due to foodborne diseases was estimated at 215 (in 2013 this was 236). The incidence of sequelae was similar between 2013 and 2014 (Table 6).

3.3 Disease burden by pathogen

The burden by pathogen is presented in Table 7 and Figure 2. The total burden of the 14 pathogens decreased by 600 DALY from 13,200 DALY in 2013 to 12,600 DALY in 2014. Predominant changes compared to 2013 were for *Campylobacter* (+240 DALY), *L. monocytogenes* (+170 DALY), *Salmonella* (-180 DALY) and rotavirus (-850 DALY). The largest burden at population level was caused by *Toxoplasma gondii* and *Campylobacter* (both ~3,500 DALY), followed by norovirus (~1,700 DALY). Perinatal listeriosis was the disease outcome with the highest individual burden among all pathogens (45 DALY per case), followed by congenital toxoplasmosis (6.3 DALY per case).

3.4 Cost of illness by pathogen

The total COI was 45 M€ lower in 2014 compared to 2013 and was estimated at 379 M€ (discounted at 4%) (Table 8). The three pathogens causing the largest discounted COI are norovirus (106 M€), *Campylobacter* spp. (76 M€) and *S. aureus* (58 M€). The lowest contribution to the COI was by hepatitis E-virus (0.2 M€). The average cost per case were largest for perinatal *Listeria* (0.2 M€, discounted), followed by congenital *Toxoplasma gondii* infections (0.05 M€, discounted). The trends in COI compared to 2013 followed the trends in DALYs.

3.5 Attribution

The attribution results for DALYs and COI are presented in Tables 9 and 10. The foodborne disease burden increased by 100 DALY from 5,800 DALY in 2013 to approximately 5,900 DALY in 2014. Fifty-five percent of the foodborne burden was associated with meat (pork 21%, poultry 18% and beef & lamb 16%). These foods caused 30% of all food-related cases, indicating that the pathogens associated with these foods tend to cause more severe infections than pathogens associated with other foods.

The total food-related COI decreased by 4% from 172 M€ to 165 M€. Approximately 45% of the COI was associated with meat and 50% with foods of animal origin.

4 Discussion

The estimated disease burden of 14 enteric pathogens in 2014 is lower by about 600 DALYs to 12,600 compared to 2013, continuing the decrease since 2012. The share of foodborne transmission in this burden increased by 100 DALY from 5,800 to 5,900 DALY. These estimates are the lowest since 2009, the first year in which the burden for all 14 pathogens was estimated. The overall COI estimates decreased by 45 M€ to 379 (discounted at 4%), and the foodborne COI decreased by approximately 7 M€ to ~165 M€ compared to 2013. The decrease in costs was a result of lower incidences for predominantly rotavirus in 2014 compared to 2013. A range of hypotheses has been proposed to explain this unprecedented low rotavirus year, amongst them the very mild winter of 2014 and vaccination in neighbouring countries (12). 2015, however, reached normal levels of rotavirus infections as before, while the very mild winter of 2016 shows even lower levels of rotavirus infection than in 2014. These data will be shown in the next update of the burden estimates.

For several pathogens, no trend information is currently used, and changes in trend then reflect changes in the population structure that are however small from year to year. This statement holds for STEC O157, the toxin producers, hepatitis E virus and *Toxoplasma gondii*. Furthermore, trends for *Cryptosporidium* spp. and *Giardia* spp. are extrapolated from trends until 2007, when systematic surveillance was discontinued. Furthermore, attribution data used in this report are based on an expert elicitation study, conducted in 2006 [8]. No time-trends in the expert estimates are available. As a consequence, the changes in incidence and burden as presented in this report for these pathogens need to be interpreted with appropriate restrictions and care.

In the past years several surveillance and registration systems have been started, have been changed or were available but not used, including for STEC O157, hepatitis E virus, norovirus and *Cryptosporidium*. In 2016, approaches to include trend updates for these pathogens will be examined and applied if deemed feasible. Estimates for previous years will be recalculated where possible given the available data, to enable proper trend assessments.

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Table 1. Population in the Netherlands by age group, 2010-14

Age group	2014	2013	2012	2011	2010
0	170,953	175,587	179,653	184,007	184,586
1-4	726,716	736,615	739,083	739,099	740,295
5-11	1,338,448	1,354,657	1,378,914	1,394,007	1,405,533
12-17	1,206,685	1,196,634	1,189,120	1,184,970	1,184,064
18-64	10,467,463	10,491,737	10,527,210	10,558,770	10,522,183
65+	2,919,024	2,824,345	2,716,368	2,594,946	2,538,328
Total	16,829,289	16,779,575	16,730,348	16,655,799	16,574,989

Table 2. Live births by age of mothers in the Netherlands, 2009-14

Age of mother	2014	2013	2012	2011	2010	2009
-19	1,276	1,750	1,592	1,717	1,884	1,953
20-24	14,213	15,190	15,206	15,782	16,417	16,499
25-29	50,307	46,616	50,371	50,295	51,570	51,459
30-34	68,120	65,651	67,489	69,174	69,420	68,828
35-39	33,797	35,489	33,725	35,340	37,213	38,637
40-44	7,046	6,378	7,212	7,393	7,565	7,252
45+	422	267	364	359	328	287
Total	175,181	171,341	175,959	180,060	184,397	184,915

Table 3. Trends in incidence per 100,000 population of food-related pathogens, 1999-2014

Year	Ca*	Sa	RV	NV	aLm	aLm fatal	pLm	pLm fatal	O157	O157 hosp	HAV	HAV hosp
	(a)	(a)	(a)	(a)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
1999	38.7	21.1	19.2		14.2				36			
2000	42.1	20.3	15.7		12.8				43			
2001	44.3	20.4	17.5		11.2				41			
2002	40.8	15.4	16.5		11.8				49			
2003	33.3	20.7	17.5		12.6				57			
2004	40.0	15.6	15.4		13.2				37			
2005	43.8	12.9	21.4	15.6	85	15	6		53			
2006	40.0	16.0	25.5	17.3	59	17	5	1	40		258	39
2007	40.7	11.9	20.1	14.5	60	12	6	1	83		168	27
2008	39.2	15.7	27.1	18.1	51	6	1	1	45		183	35
2009	44.1	11.6	30.9	17.7	76	4	3	1	57	21	176	29
2010	50.2	13.8	35.2	22.2	73	13	4	1	52	21	262	52
2011	51.3	12.2	23.7	19.4	79	4	9	1	65	18 [†]	125	25
2012	48.8	20.7	20.1	19.7	71	8	6	0	85	31 [‡]	121	28
2013	48.0	9.3	23.3	18.6	76	7	3	0	90	36 ^{**}	109	30
2014	47.5	9.2	9.6	18.4 ^{##}	92	9	4	2	79	31 ^{††}	105	23

Data sources: see text; * Ca: *Campylobacter* spp.; Sa: *Salmonella* spp.; RV: rotavirus; NV: norovirus; aLm: acquired listeriosis; pLm: perinatal listeriosis; O157: STEC O157; HAV: hepatitis A-virus; hosp: hospitalized; [†] known for 57 of the 65 cases; [‡] known for 77 of the 85 cases; ^{**} known for 84 of the 90 cases; ^{††} known for 71 of the 79 cases; (a) per 100,000 inhabitants; (b) reported cases; ^{‡‡} based on ICD10 codes instead of ICD9 and not directly comparable to numbers from before 2012

Table 4. Mean incidence and 95% interval (between brackets) of gastroenteritis by pathogen in the Netherlands, 2014

Pathogen	General population (x 1,000)	GP visit (x 1,000)	Hospitalised (x 1,000)	Fatal cases
All causes	4,804 (3,996 - 5,709)	222 (71 - 512)	20 -	NA*
Bacteria – infectious				
<i>Campylobacter</i> spp.	98 (14 - 272)	24 (12 - 44)	1.1 (0.4 - 2.2)	57 (33 - 75)
STEC O157	2.1 (0.2 - 8.4)	0.3 (0.01 - 0.9)	0.03 -	1 (0 - 3)
<i>Salmonella</i> spp.	27 (2.5 - 8.2)	4.2 (2.2 - 6.9)	1.0 (0.4 - 2.0)	27 (22 - 28)
Bacteria – toxin producing				
<i>Bacillus cereus</i>	52 (18 - 122)	7.2 (1.7 - 20)	0.2 (0.07 - 0.5)	0 -
<i>Clostridium perfringens</i>	170 (57 - 368)	31 (7.4 - 80)	0.3 (0.01 - 0.6)	5 (0 - 19)
<i>Staphylococcus aureus</i>	291 (127 - 551)	40 (11 - 97)	1.5 (0.6 - 2.8)	7 (0 - 29)
Viruses				
Norovirus	656 (445 - 947)	15 (9 - 24)	1.7 (0.8 - 3.0)	68 (48 - 214)
Rotavirus	124 (62 - 222)	7.5 (4.7 - 11)	4.8 (3.4 - 6.7)	20 (6 - 43)
Protozoa				
<i>Cryptosporidium</i> spp.	28 (8.6 - 69)	1.7 (0.8 - 3.0)	0.5 (0.2 - 1.1)	2 (0 - 7.6)
<i>Giardia</i> spp.	49 (24 - 95)	4.3 (2.2 - 7.6)	0.4 (0.04 - 1.4)	1 (0 - 5.4)

* not available

Table 5. Mean incidence and 95% interval (between brackets) of non-gastrointestinal pathogens in the Netherlands, 2014

Pathogen	Incidence	Fatal cases
<i>Listeria monocytogenes</i>		
Perinatal	4	2
Acquired	92	9
Hepatitis A virus	515 (278 – 905)	2 1 - 3
Hepatitis E virus	53 (22 – 95)	1 0 - 1
<i>Toxoplasma gondii</i>		
Congenital	355 (183 – 618)	12 7 - 21
Acquired**	423 (197 – 722)	0

* No uncertainty because *Listeria* cases were acquired through active surveillance;

** chorioretinitis only

Table 6. Incidence of sequelae by pathogen in the Netherlands, 2014

Pathogen and sequelae	Incidence		Fatal cases	
	Mean	95% CI	Mean	95% CI
<i>Campylobacter</i> spp.				
Guillain-Barré Syndrome	147	4 - 255	1	0 - 5
Reactive arthritis	1,794	747 - 3,610	0	-
Irritable Bowel Syndrome	8,629	2,510 - 22,257	0	-
Inflammatory Bowel Disease	29	21 - 39	0	-
STEC O157				
Hemolytic Uraemic Syndrome	22	15 - 30	2	1 - 5
End-Stage Renal Disease	3	1 - 5	1	-
<i>Salmonella</i> spp.				
Reactive arthritis	341	120 - 712	0	-
Irritable Bowel Syndrome	2,318	358 - 6,923	0	-
Inflammatory Bowel Disease	5	4 - 7	0	-
<i>Listeria monocytogenes</i> (perinatal)				
Meningitis	2*		NA	
Neurological sequelae of meningitis	1	0 - 1	0	-
<i>Listeria monocytogenes</i> (acquired)				
Meningitis	22	19 - 25	NA	
Neurological sequelae of meningitis	3	2 - 5	0	-
<i>Toxoplasma gondii</i> (congenital)				
Chorioretinitis 1 st year of life	48	24 - 84	NA	
Chorioretinitis later years of life	57	30 - 100	NA	
Intracranial calcifications	37	19 - 67	NA	
Hydrocephalus	7	3 - 13	NA	
Central Nervous System Abnormalities	10	2 - 28	NA	
<i>Toxoplasma gondii</i> (acquired)				
Chorioretinitis	423	197 - 722	0	-

† mean; ‡ 2.5-97.5 percentile; * no uncertainty because cases were acquired through active surveillance; NA: not applicable (fatal cases are reported in Table 2)

Table 7. Estimated total DALY, DALY per 100,000 inhabitants and mean DALY per case of illness in the Netherlands, 2014

Pathogen	DALY per year		DALY per 100,000		DALY per 1,000 cases		
	Discount rate	0%	1.5%	0%	1.5%	0%	1.5%
Bacteria – infectious							
<i>Campylobacter</i> spp.		3,650	3,224	22	19	37	33
STEC O157		138	109	1	1	65	51
<i>Salmonella</i> spp.		920	816	5	5	34	30
<i>L. monocytogenes</i> (perinatal)		181	105	1.1	0.6	45,191	26,296
<i>L. monocytogenes</i> (acquired)		81	78	0.5	0.5	886	849
<i>L. monocytogenes</i> (total)		262	183	2	1	2,732	1,909
Bacteria – toxin producing							
<i>Bacillus cereus</i>		116	116	1	1	2	2
<i>Clostridium perfringens</i>		540	535	3	3	3	3
<i>Staphylococcus aureus</i>		762	754	5	4	3	3
Viruses							
Norovirus		1,683	1,498	10	9	3	2
Rotavirus		756	691	4	4	6	6
Hepatitis A virus		85	74	1	0	165	143
Hepatitis E virus		24	20	0	0	459	378
Protozoa							
<i>Cryptosporidium</i> spp.		69	67	0.4	0.4	2.5	2.4
<i>Giardia</i> spp.		101	100	0.6	0.6	2.1	2.1
<i>Toxoplasma gondii</i> (congenital)		2,158	1,267	13	7.5	6,345	3,723
<i>Toxoplasma gondii</i> (acquired)		1,341	1,016	8.0	6.0	3,173	2,405
<i>Toxoplasma gondii</i> (total)		3,495	2,281	21	14	4,566	2,973

Table 8. Estimated total costs of illness (COI), COI per 100,000 inhabitants and mean COI per case of illness in the Netherlands, 2014

Pathogen	COI ^a per year (M€)		COI ^a per 100,000 (k€)		COI ^a per 1,000 cases (k€)		
	Discount rate	0%	4%	0%	4%	0%	4%
Bacteria – infectious							
<i>Campylobacter</i> spp.		83	76	491	453	843	777
STEC O157		5	2	31	13	2,436	1,068
<i>Salmonella</i> spp.		20	19	120	112	733	687
<i>L. monocytogenes</i> (perinatal)		1.9	0.7	12	4	486,960	181,181
<i>L. monocytogenes</i> (acquired)		2.8	2.7	17	16	30,852	28,906
<i>L. monocytogenes</i> (total)		4.8	3.4	28	20	50	35
Bacteria – toxin producing							
<i>Bacillus cereus</i>		10	10	60	60	195	195
<i>Clostridium perfringens</i>		27	27	163	163	161	161
<i>Staphylococcus aureus</i>		57	57	337	337	195	195
Viruses							
Norovirus		106	106	631	631	162	162
Rotavirus		39	39	230	230	312	312
Hepatitis A virus		1	1	5	5	1,504	1,504
Hepatitis E virus		0	0	1	1	4,526	4,526
Protozoa							
<i>Cryptosporidium</i> spp.		8	8	48	48	290	290
<i>Giardia</i> spp.		10	10	57	57	197	197
<i>Toxoplasma gondii</i> (congenital)		55	18	326	106	153,860	50,040
<i>Toxoplasma gondii</i> (acquired)		3	3	18	18	7,001	6,992
<i>Toxoplasma gondii</i> (total)		58	21	343	123	74,266	26,707
TOTAL		428	379	2,544	2,253		

^a costs are expressed in 2014 euros

Table 9. Attribution of the incidence, fatalities, disease burden and Cost-of-Illness to the major transmission pathways in the Netherlands, 2014*

Main pathway	Food	Environment	Human	Animal	Travel	Total
Incidence (per year)	646,364	172,657	482,160	77,655	118,597	1,497,433
Deaths (per year)	80	36	58	20	23	215
Disease burden (DALY)	5,892	2,644	1,855	1,071	1,140	12,602
Disease burden (DALY, discounted)	4,860	2,052	1,656	927	973	10,468
Cost of illness (M€, undiscounted) ^a	192	71	98	31	37	428
Cost of illness (M€, discounted at 4%) ^a	165	55	97	28	34	379

* due to the 14 pathogens included in this study

^a costs are expressed in 2014 euros

Table 11. Attribution of the incidence, fatalities, disease burden and Cost-of-Illness of foodborne disease* to food groups in the Netherlands, 2014

Food group	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Incidence (per year)	105,585	43,901	59,384	21,127	54,264	50,817	34,429	14,799	39,332	120,279	102,447	646,364
Deaths (per year)	8.9	8.9	17	4.8	6.8	6.9	5.3	1.8	3.0	5.2	11	80
Disease burden (DALY)	922	1,263	1,105	212	441	374	344	89	172	447	525	5,892
Disease burden (DALY, discounted)	737	897	962	190	374	316	282	80	159	414	448	4,860
Cost of illness (M€, undiscounted) ^a	29	27	29	6.7	16	13	11	3.6	8.7	25	23	192
Cost of illness (M€, discounted at 4%) ^a	23	16	26	6.4	14	12	9	3.5	8.5	25	21	165

* due to the 14 pathogens included in this study

^a costs are expressed in 2014 euros

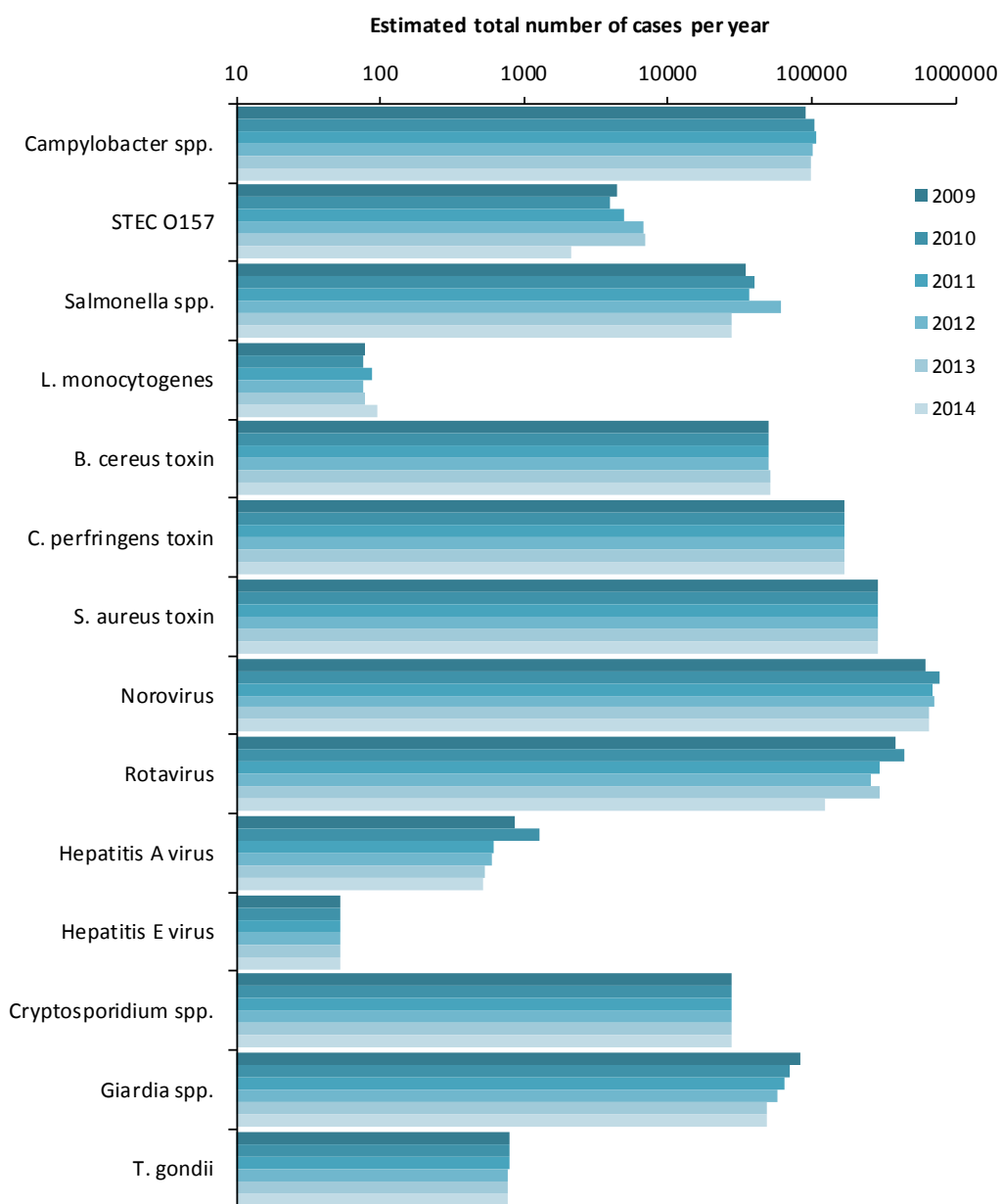


Figure 1. Comparison of incidence of food-related pathogens in 2009 through 2014.

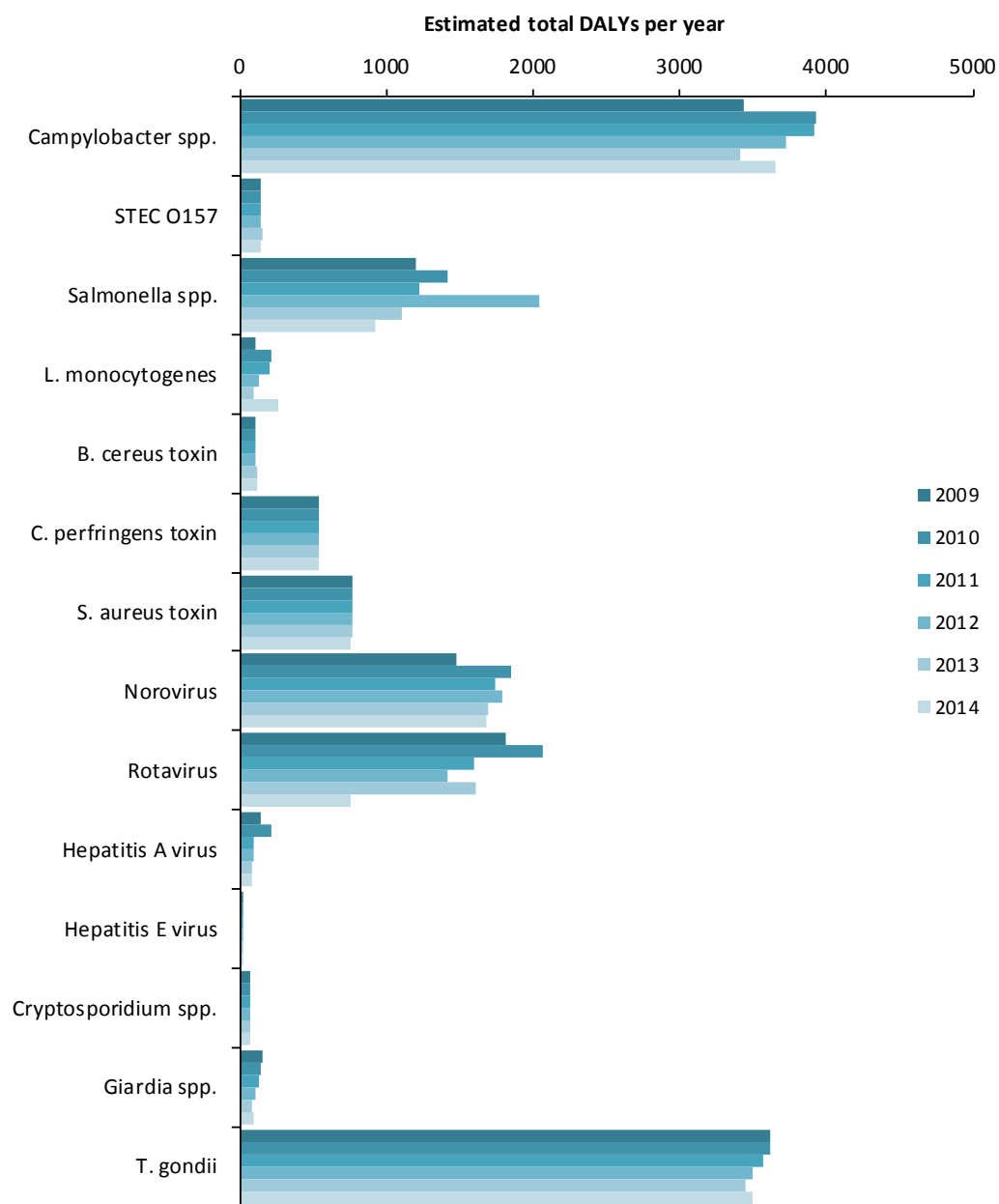


Figure 2. Comparison of disease burden of food-related pathogens in 2009 through 2014.

Annex. Detailed results

Summary of results

Pathogen	Incidence (per year)	Deaths (per year)	Disease burden (DALY)	Costs (M€ per jaar)	
				Disc. 0%	Disc. 4%
Campylobacter	98,091	57	3,650	83	76
STEC O157	2,123	4	138	5	2
L. monocytogenes	96	11	262	5	3
Salmonella	27,475	27	920	20	19
B. cereus toxine	51,604	0	116	10	10
C. perfringens toxine	170,286	5	540	27	27
S. aureus toxine	290,782	7	762	57	57
Hepatitis-A virus	514	2	85	1	1
Hepatitis-E virus	53	1	24	0.2	0.2
Norovirus	655,580	68	1,683	106	106
Rotavirus	123,945	20	756	39	39
C. parvum	27,583	2	69	8	8
G. lamblia	48,524	1	101	10	10
T. gondii	777	12	3,495	58	21
Totaal	1,497,433	215	12,602	428	379

* Note: Costs are expressed in 2014 euros.

Attribution of incidence by pathogen to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter	41.198	20.207	6.180	18.735	11.771	98.091
STEC O157	858	365	217	435	248	2.123
L. monocytogenes	66	6	5	5	13	96
Salmonella	14.974	3.544	2.555	2.528	3.874	27.475
B. cereus toxine	46.082	568	619	568	3.767	51.604
C. perfringens toxine	153.938	3.746	3.576	3.576	5.449	170.286
S. aureus toxine	253.562	10.468	9.305	6.397	11.050	290.782
Hepatitis-A virus	59	57	94	0	305	514
Hepatitis-E virus	7	13	4	6	23	53
Norovirus	109.482	93.092	363.191	32.779	57.035	655.580
Rotavirus	16.113	21.071	72.012	3.718	11.031	123.945
C. parvum	3.282	7.641	7.558	3.696	5.406	27.583
G. lamblia	6.308	11.597	16.838	5.192	8.589	48.524
T. gondii	434	281	7	19	36	777
Total	646.364	172.657	482.160	77.655	118.597	1.497.433

Attribution of deaths by pathogen to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Totaal
Campylobacter	24,0	11,8	3,6	10,9	6,9	57,2
STEC O157	1,6	0,7	0,4	0,8	0,5	4,0
L. monocytogenes	7,6	0,7	0,6	0,6	1,5	11,0
Salmonella	14,5	3,4	2,5	2,4	3,7	26,6
B. cereus toxine	0,0	0,0	0,0	0,0	0,0	0,0
C. perfringens toxine	4,1	0,1	0,1	0,1	0,1	4,6
S. aureus toxine	6,3	0,3	0,2	0,2	0,3	7,2
Hepatitis-A virus	0,2	0,2	0,3	0,0	1,0	1,6
Hepatitis-E virus	0,1	0,2	0,0	0,1	0,3	0,6
Norovirus	11,3	9,6	37,4	3,4	5,9	67,5
Rotavirus	2,6	3,3	11,4	0,6	1,8	19,7
C. parvum	0,2	0,5	0,5	0,2	0,3	1,7
G. lamblia	0,2	0,3	0,5	0,1	0,2	1,4
T. gondii	6,9	4,5	0,1	0,3	0,6	12,4
Total	79,5	35,6	57,6	19,8	23,0	215,5

Attribution of disease burden (DALY per year, undiscounted) to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter	1.533	752	230	697	438	3.650
STEC O157	56	24	14	28	16	138
L. monocytogenes	181	18	14	14	35	262
Salmonella	502	119	86	85	130	920
B. cereus toxine	104	1	1	1	8	116
C. perfringens toxine	488	12	11	11	17	540
S. aureus toxine	665	27	24	17	29	762
Hepatitis-A virus	10	9	15	0	50	85
Hepatitis-E virus	3	6	2	3	10	24
Norovirus	281	239	933	84	146	1.683
Rotavirus	98	129	439	23	67	756
C. parvum	8	19	19	9	13	69
G. lamblia	13	24	35	11	18	101
T. gondii	1.950	1.265	31	87	161	3.495
Total	5.892	2.644	1.855	1.071	1.140	12.602

Attribution of cost-of-illness (k€ per year, discounted at 4% and expressed in 2014 euros) to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter	32.007	15.699	4.801	14.556	9.145	76.207
STEC O157	916	390	231	465	265	2.268
L. monocytogenes	2.340	227	179	183	453	3.382
Salmonella	10.289	2.435	1.756	1.737	2.662	18.878
B. cereus toxine	8.976	111	121	111	734	10.052
C. perfringens toxine	24.732	602	575	575	875	27.358
S. aureus toxine	49.490	2.043	1.816	1.249	2.157	56.754
Hepatitis-A virus	88	86	141	0	459	773
Hepatitis-E virus	33	60	18	26	103	239
Norovirus	17.731	15.076	58.819	5.309	9.237	106.172
Rotavirus	5.033	6.581	22.493	1.161	3.446	38.714
C. parvum	952	2.217	2.193	1.072	1.568	8.002
G. lamblia	1.245	2.289	3.323	1.025	1.695	9.577
T. gondii	11.586	7.516	187	519	955	20.764
Total	165.418	55.331	96.652	27.985	33.753	379.139

Attribution of incidence by pathogen to food groups

Pathogen											Humans &	Total
	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	animals	
Campylobacter	1.689	2.101	22.206	1.277	3.667	2.884	2.184	700	948	1.360	2.184	41.198
STEC O157	378	55	27	18	63	25	61	31	25	30	145	858
L. monocytogenes	7	6	4	3	16	12	5	2	4	4	3	66
Salmonella	1.887	2.141	2.216	3.324	988	614	943	464	644	898	853	14.974
B. cereus toxine	3.318	1.613	737	1.659	2.673	922	922	783	7.788	24.562	1.106	46.082
C. perfringens toxine	73.583	12.931	10.930	4.310	6.311	10.006	10.622	3.848	4.002	11.853	5.542	153.938
S. aureus toxine	19.017	20.539	19.778	8.368	37.274	14.707	5.071	4.564	19.017	75.054	30.174	253.562
Hepatitis-A virus	0	0	0	0	0	7	7	3	3	2	37	59
Hepatitis-E virus	0	5	0	0	0	0	1	0	0	0	1	7
Norovirus	3.503	3.394	3.175	2.080	2.190	16.970	7.992	3.394	5.693	5.474	55.617	109.482
Rotavirus	0	451	0	0	274	3.126	3.835	709	1.208	725	5.785	16.113
C. parvum	860	144	95	89	302	716	679	98	0	98	200	3.282
G. lamblia	1.243	303	196	0	486	814	2.082	202	0	208	776	6.308
T. gondii	99	218	21	0	20	16	25	0	0	10	25	434
Total	105.585	43.901	59.384	21.127	54.264	50.817	34.429	14.799	39.332	120.279	102.447	646.364

Attribution of deaths by pathogen to food groups

Pathogen											Humans &	Total
	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	animals	
Campylobacter	1,0	1,2	13,0	0,7	2,1	1,7	1,3	0,4	0,6	0,8	1,3	24,0
STEC O157	0,7	0,1	0,1	0,0	0,1	0,0	0,1	0,1	0,0	0,1	0,3	1,6
L. monocytogenes	0,9	0,7	0,5	0,3	1,9	1,4	0,6	0,2	0,4	0,4	0,4	7,6
Salmonella	1,8	2,1	2,1	3,2	1,0	0,6	0,9	0,4	0,6	0,9	0,8	14,5
B. cereus toxine	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C. perfringens toxine	2,0	0,3	0,3	0,1	0,2	0,3	0,3	0,1	0,1	0,3	0,1	4,1
S. aureus toxine	0,5	0,5	0,5	0,2	0,9	0,4	0,1	0,1	0,5	1,9	0,7	6,3
Hepatitis-A virus	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2
Hepatitis-E virus	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1
Norovirus	0,4	0,3	0,3	0,2	0,2	1,7	0,8	0,3	0,6	0,6	5,7	11,3
Rotavirus	0,0	0,1	0,0	0,0	0,0	0,5	0,6	0,1	0,2	0,1	0,9	2,6
C. parvum	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2
G. lamblia	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,2
T. gondii	1,6	3,5	0,3	0,0	0,3	0,3	0,4	0,0	0,0	0,2	0,4	6,9
Total	8,9	8,9	17,1	4,8	6,8	6,9	5,3	1,8	3,0	5,2	10,8	79,5

Attribution of disease burden (DALY per year, undiscounted) to food groups

Pathogen	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter	63	78	826	48	136	107	81	26	35	51	81	1.533
STEC O157	25	4	2	1	4	2	4	2	2	2	9	56
L. monocytogenes	20	17	12	7	45	32	14	5	11	10	9	181
Salmonella	63	72	74	111	33	21	32	16	22	30	29	502
B. cereus toxine	7	4	2	4	6	2	2	2	18	55	2	104
C. perfringens toxine	233	41	35	14	20	32	34	12	13	38	18	488
S. aureus toxine	50	54	52	22	98	39	13	12	50	197	79	665
Hepatitis-A virus	0	0	0	0	0	1	1	0	0	0	6	10
Hepatitis-E virus	0	2	0	0	0	0	0	0	0	0	0	3
Norovirus	9	9	8	5	6	44	21	9	15	14	143	281
Rotavirus	0	3	0	0	2	19	23	4	7	4	35	98
C. parvum	2	0	0	0	1	2	2	0	0	0	0	8
G. lamblia	3	1	0	0	1	2	4	0	0	0	2	13
T. gondii	447	979	94	0	90	72	113	0	0	45	111	1.950
Total	922	1.263	1.105	212	441	374	344	89	172	447	525	5.892

Attribution of cost-of-illness (k€ per year, discounted at 4% and expressed in 2014 euros) to food groups

Attribution of cost of illness (Rs per year) discounted at 7% and expressed in 2014 euros) to food groups												
	Livestock					Plant-based				Humans & animals		
Pathogen	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	animals	Total
Campylobacter	1.312	1.632	17.252	992	2.849	2.240	1.696	544	736	1.056	1.696	32.007
STEC O157	404	59	28	19	68	27	65	33	27	32	155	916
L. monocytogenes	262	218	154	89	578	417	178	61	138	131	115	2.340
Salmonella	1.296	1.471	1.523	2.284	679	422	648	319	442	617	586	10.289
B. cereus toxine	646	314	144	323	521	180	180	153	1.517	4.784	215	8.976
C. perfringens toxine	11.822	2.077	1.756	692	1.014	1.608	1.706	618	643	1.904	890	24.732
S. aureus toxine	3.712	4.009	3.860	1.633	7.275	2.870	990	891	3.712	14.649	5.889	49.490
Hepatitis-A virus	0	0	0	0	0	11	11	3,9	3,9	2,7	55	88
Hepatitis-E virus	0	24	0	0	0	1,6	2,4	1,2	0,0	0,0	3,4	33
Norovirus	567	550	514	337	355	2.748	1.294	550	922	887	9.007	17.731
Rotavirus	0	141	0	0	86	976	1.198	221	377	226	1.807	5.033
C. parvum	249	42	28	26	88	208	197	29	0	29	58	952
G. lamblia	245	60	39	0	96	161	411	40	0	41	153	1.245
T. gondii	2.653	5.816	556	0	533	429	672	0	0	266	660	11.586
Total	23.170	16.413	25.854	6.396	14.140	12.297	9.249	3.463	8.518	24.626	21.292	165.418

