



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

Disease burden of food-related pathogens in the Netherlands, 2015

RIVM Letter report 2017-0060
M.J. Mangen et al.



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Colophon

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Synopsis

Disease burden of food-related pathogens in the Netherlands, 2015

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 disease burden is expressed in DALYs (Disability Adjusted Life Years), a metric integrating morbidity and mortality into one metric unit. Furthermore, the cost-of-illness (COI) related to the 14 food-related pathogens was estimated and expressed in euros. The total disease burden caused by the 14 pathogens increased from around 12,600 DALY in 2014 to 12,800 DALY in 2015. The share of foodborne transmission in this estimated burden was comparable to earlier years, mounting to 5,800 DALY in 2015. The food-related COI were slightly increased from 166 M€ in 2014 to 168 M€ for 2015. The increase in both, burden and in costs, in the estimates is possibly related to the significant larger incidence of rotavirus infections compared to 2014.

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 2015

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 2015 geschat op 5,800, en is daarmee iets lager dan in 2014 (5.900 DALY's).

Daarnaast wordt geschat welke kosten hieraan verbonden zijn (cost-of-illness). Deze omvatten directe medische kosten, maar ook de kosten voor de patiënt en/of zijn familie, zoals reiskosten, als ook de kosten binnen andere sectoren, bijvoorbeeld door werkverzuim. De gerelateerde kosten van de 14 ziekteverwekkers die mensen via voedsel opliepen was met 168 miljoen euro iets hoger dan in 2014 (166 miljoen euro). De verschillen zijn grotendeels een gevolg van schommelingen in de infecties die zich voordoen, de ziektebelasting die ze veroorzaken en uiteenlopende kosten per infectie.

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' is geschat op 12.800 DALY, en daarmee iets hoger dan in 2014 (12.600 DALY). De totale kosten werden geschat op 409 miljoen euro en waren daarmee hoger dan in 2014 (385 miljoen). Een belangrijke oorzaak hiervan is een verdubbeling van aantal rotainfecties ten opzichte van 2014.

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[1-6]. 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) are expressed in euros, and are also described in detail in a peer-reviewed paper [7]. 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) were used to update the information to the year 2015.

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
- Shiga-toxin producing *Escherichia coli* O157 (STEC O157): RIVM-OSIRIS, active 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 and toxoplasmosis. 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 and from the Dutch Hospital Data (DHD) for 2011-2014. Based on the observed time series from the laboratory surveillance (primarily tested faeces) estimates for the number of hospitalized patients in 2015 were derived by taking the average for the number of hospitalized patients in 2011-2013.

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 and 2013 to estimate the proportional increase due to the new reporting system. Based on ICD9 3293 (2012) and 3132 (2013) cases were

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

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. The same methodology was applied for 2015.

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

The method for cost-of-illness calculations were not changed compared to previous years (i.e. 2011 and onwards), only the cost prices used for the different resources had to be updated to 2015 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- 2014) to 2015 euros; hence all differences in the results for the year 2015 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=51,142,181,194,219,232,245,258,I&HDR=G1,T&STB=G2&VW=T>, accessed December 6th, 2016

3 Results

3.1 Trend information

Trend information for specific pathogens is presented in Table 3. A summary of trends (in comparison with 2014) is discussed below:

- The incidence of campylobacteriosis (laboratory confirmed cases) decreased from 47.5 to 42.8 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 2014 with 9.0 per 100,000 inhabitants. The reported incidence rate for 2013-2015 were the lowest since 1999 (21.1 per 100,000).
- The incidence of gastroenteritis by rotavirus (laboratory confirmed cases) was with 20.4 per 100,000 inhabitants more than the double than in 2014 (9.5 per 100,000), but similar to the years 2013 and 2012 (23.3 and 20.1 per 100,000).
- The incidence of acquired listeriosis (active surveillance) decreased from 92 cases in 2014 to 72 cases in 2015, and was similar to earlier years. However, the recorded fatalities increased markedly from 9 in 2014 to 15 in 2015. Similar or even higher fatalities were previously only reported for 2005 (15 cases) and for 2006 (17 cases).
- The incidence of perinatal listeriosis (active surveillance) was 3 cases with 1 fatalities. The number of perinatal cases and mortality were similar to previous years.
- The incidence of diseases caused by STEC O157 (active surveillance) was 76 cases with 27 hospitalizations (of 68 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 with 3 in 2015, similar to 2014.
- 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 2006-2015. The number of hospitalizations, was similar to 2014, with the proportion of hospitalized patients being 23%.
- The number of GE hospitalization was estimated to be 22,200 in 2015, and therefore slightly higher than in 2014 (20,345), but similar to earlier years. The observed increase in 2015 was mainly driven by the far higher number of rotavirus infections in 2015, compared to 2014. Note, opposite to earlier years, were the number of hospitalization estimated.

3.2 Disease incidence

The incidence of gastroenteritis by pathogen, of disease by non-gastrointestinal pathogens and of sequelae by pathogen in 2015 is presented in Tables 4-6, and Figure 1. Overall there were no marked increases in incidence compared to 2014, with one exception, namely rotavirus. The estimated total number of foodborne cases due to the 14

pathogens increased from 1,500,000 in 2014 to 1,620,000 in 2015, which was similar to 2013. The total number of deaths due to foodborne diseases increased from 215 in 2014 to 241 in 2015, but was similar to earlier years (i.e. 236 in 2013). The incidence of sequelae in 2015 (Table 6) was similar with previous years.

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 increased by 200 DALY from 12,600 DALY in 2014 to 12,800 DALY in 2015, but was lower than in earlier years. Predominant changes compared to 2014 were for *Campylobacter* (-345 DALY) and rotavirus (+680 DALY). The largest burden at population level was caused by *Toxoplasma gondii* (3,400 DALY) and *Campylobacter* (3,300 DALY), followed by norovirus (1,780 DALY). Perinatal listeriosis was the disease outcome with the highest individual burden among all pathogens (33 DALY per case), followed by congenital toxoplasmosis (6.1 DALY per case).

3.4 Cost of illness by pathogen

The total COI was 25 M€ higher in 2015 compared to 2014 and was estimated at 409 M€ (discounted at 4%) (Table 8 and Figure 3). The three pathogens causing the largest discounted COI are norovirus (110 M€), rotavirus (70 M€) and *Campylobacter* spp. (69 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* (0.23 M€, discounted), followed by congenital *Toxoplasma gondii* infections (0.05 M€, discounted). The trends in COI compared to 2014 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 decreased by 100 DALY from 5,900 DALY in 2014 to approximately 5,800 DALY in 2015, and were similar to 2013 (5,800 DALY). Fifty-five percent of the foodborne burden was associated with meat (pork 26%, poultry 21% and beef & lamb 19%). These foods caused 31% 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 increased by 1% from 166 M€ to 168 M€. Approximately 38% 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 2015 is higher by about 200 DALYs to 12,800 compared to 2014. But compared to earlier years, there is still a continuing decrease since 2012. The share of foodborne transmission in this burden decreased by 100 DALY from 5,900 to 5,800 DALY, and is similar with 2013. These estimates are the lowest since 2009, the first year in which the burden for all 14 pathogens was estimated. The overall COI estimates increased by 25 M€ to 409 (discounted at 4%) compared to 2014 (385 m€), and the foodborne COI increased by approximately 2 M€ to 168 M€. The increase in costs was a result of higher incidences for predominantly rotavirus in 2015 compared to 2014. A range of hypotheses has been proposed to explain this unprecedented low rotavirus year in 2014, amongst them the very mild winter of 2014 and vaccination in neighboring countries, 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 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 hepatitis E virus, norovirus and *Cryptosporidium*. In 2017, 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, 2011-15

Age group	2015	2014	2013	2012	2011
0	174,681	170,953	175,587	179,653	184,007
1-4	713,641	726,716	736,615	739,083	739,099
5-11	1,324,894	1,338,448	1,354,657	1,378,914	1,394,007
12-17	1,215,977	1,206,685	1,196,634	1,189,120	1,184,970
18-64	10,463,848	10,467,463	10,491,737	10,527,210	10,558,770
65+	3,007,685	2,919,024	2,824,345	2,716,368	2,594,946
Total	16,900,726	16,829,289	16,779,575	16,730,348	16,655,799

Table 2. Live births by age of mothers in the Netherlands, 2011-15

Age of mother	2015	2014	2013	2012	2011
-19	1,109	1,276	1,360	1,592	1,717
20-24	13,125	14,213	14,581	15,206	15,782
25-29	48,724	50,307	49,342	50,371	50,295
30-34	66,373	68,120	65,925	67,489	69,174
35-39	34,070	33,797	32,939	33,725	35,340
40-44	6,733	7,046	6,836	7,212	7,393
45+	376	422	358	364	359
Total	170,510	175,181	171,341	175,959	180,060

Table 3. Trends in incidence per 100,000 population of food-related pathogens, 1999-2015

Year	Ca (a)*	Sa (a)*	RV (a)*	NV (a)*	aLm (b)*	aLm fatal (b)*	pLm (b)*	pLm fatal (b)*	O157 (b)*	O157 hosp (b)*	HAV (b)*	HAV hosp (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	9.5	18.4 ^{##}	92	9	4	2	79	31 ^{††}	105	23
2015	42.8	9.0	20.4	18.4 ^{###}	72	15	3	1	76	27 ^{&}	80	23

Used abbreviations:

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;

Notes:

*(a) per 100,000 inhabitants; (b) reported cases;

based on ICD10 codes instead of ICD9 and not directly comparable to numbers from before 2012

2015 was estimated by multiplying the 2014 incidence by a correction factor. Correction factor represented the average trend for hospitalization and surveillance data.

[†]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;

[&] known for 68 of the 76 cases;

Data sources:

see text;

Table 4. Mean incidence and 95% interval (between brackets) of gastroenteritis by pathogen in the Netherlands, 2015

Pathogen	General population (x 1,000)	GP visit (x 1,000)	Hospitalised (x 1,000)	Fatal cases
All causes	4,803 (3,983 - 5,713)	223 (71 - 522)	22 -	NA#
Bacteria – infectious				
<i>Campylobacter</i> spp.	88 (12 - 245)	22 (11 - 40)	1.1 (0.4 - 2.2)	54 (35-74)
STEC O157	2.1 (0.2 - 8.7)	0.2 (0.01 - 0.9)	0.02 -	1 0 - 3
<i>Salmonella</i> spp.	28 (2.2 - 83)	4.1 (0.2 - 7.0)	1.1 (0.4 - 2.2)	25 (22 - 29)
Bacteria – toxin producing				
<i>Bacillus cereus</i>	52 (17 - 122)	7.2 (1.6 - 20)	0.2 (0.07 - 0.5)	0 -
<i>Clostridium perfringens</i>	169 (56 - 374)	31 (7.3 - 80)	0.3 (0.01 - 0.6)	5 (0.1 - 20)
<i>Staphylococcus aureus</i>	288 (124 - 546)	40 (11 - 96)	1.5 (0.6 - 2.8)	7 (0.1 - 29)
Viruses				
Norovirus	667 (488 - 1,025)	17 (9.1 - 25)	1.9 (1.0 - 3.3)	71 (30 - 133)
Rotavirus	261 (128 - 466)	16 (10 - 24)	5.4 (4.3 - 7.6)	42 (14 - 94)
Protozoa				
<i>Cryptosporidium</i> spp.	28 (8.6 - 67)	1.7 (0.8 - 2.9)	0.6 (0.2 - 1.2)	2 (0.03 - 7.5)
<i>Giardia</i> spp.	41 (20 - 79)	3.7 (1.9 - 6.5)	0.5 (0.04 - 1.4)	1 (0.03 - 4.2)

* not available

Table 5. Mean incidence and 95% interval (between brackets) of non-gastrointestinal pathogens in the Netherlands, 2015

Pathogen	Incidence	Fatal cases
<i>Listeria monocytogenes</i>		
Perinatal	3	1
Acquired	72	15
Hepatitis A virus	391 (212 - 690)	1 (0.7 - 2)
Hepatitis E virus	53 (23 - 94)	1 (0.2 - 1.3)
<i>Toxoplasma gondii</i>		
Congenital	345 (177 - 606)	12 (7 - 21)
Acquired**	424 (197 - 717)	0

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

** chorioretinitis only

Table 6. Incidence of sequelae by pathogen in the Netherlands, 2015

Pathogen and sequelae	Incidence		Fatal cases	
	Mean	95% CI	Mean	95% CI
<i>Campylobacter</i> spp.				
Guillain-Barré Syndrome	67	0 - 127	1	0 - 4
Reactive arthritis	1,620	689 - 3,260	0	-
Irritable Bowel Syndrome	7,591	2,155 - 19,956	0	-
Inflammatory Bowel Disease	26	18 - 35	0	-
STEC O157				
Hemolytic Uraemic Syndrome	22	15 - 30	2	1 - 5
End-Stage Renal Disease	3	1 - 4	1	-
<i>Salmonella</i> spp.				
Reactive arthritis	341	119 - 712	0	-
Irritable Bowel Syndrome	2,319	339 - 7,015	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	17	15 - 19	NA	
Neurological sequelae of meningitis	2	1 - 4	0	-
<i>Toxoplasma gondii</i> (congenital)				
Chorioretinitis 1 st year of life	46	23 - 83	NA	
Chorioretinitis later years of life	56	29 - 98	NA	
Intracranial calcifications	36	18 - 65	NA	
Hydrocephalus	7	3 - 13	NA	
Central Nervous System Abnormalities	10	2 - 27	NA	
<i>Toxoplasma gondii</i> (acquired)				
Chorioretinitis	424	197 - 717	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, 2015

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.		3,305	2,926	20	17	37	33
STEC O157		138	110	1	1	65	52
<i>Salmonella</i> spp.		905	807	5	5	33	29
<i>L. monocytogenes</i> (perinatal)		99	58	0.6	0.3	33,000	19,333
<i>L. monocytogenes</i> (acquired)		116	110	0.7	0.7	1,611	1,528
<i>L. monocytogenes</i> (total)		215	169	1	1	2,869	2,252
Bacteria – toxin producing							
<i>Bacillus cereus</i>		118	118	1	1	2	2
<i>Clostridium perfringens</i>		541	535	3	3	3	3
<i>Staphylococcus aureus</i>		761	753	5	4	3	3
Viruses							
Norovirus		1,733	1,546	10	9	3	2
Rotavirus		1,440	1,300	9	8	6	5
Hepatitis A virus		65	56	0	0	165	143
Hepatitis E virus		24	20	0	0	458	377
Protozoa							
<i>Cryptosporidium</i> spp.		71	69	0.4	0.4	3	3
<i>Giardia</i> spp.		89	88	0.5	0.5	2	2
<i>Toxoplasma gondii</i> (congenital)		2,099	1,232	12.4	7.3	6,084	3,571
<i>Toxoplasma gondii</i> (acquired)		1,344	1,019	8.0	6.0	3,173	2,406
<i>Toxoplasma gondii</i> (total)		3,433	2,244	20	13	4,487	2,933

Table 8. Estimated total costs of illness (COI), COI per 100,000 inhabitants and mean COI per case of illness in the Netherlands, 2015

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.		75	69	445	410	850	784
STEC O157		11	5	63	32	5,044	2,573
<i>Salmonella</i> spp.		20	19	120	112	735	688
<i>L. monocytogenes</i> (perinatal)		1.9	0.7	11	4	640,857	230,574
<i>L. monocytogenes</i> (acquired)		2.4	2.3	14	13	33,465	31,572
<i>L. monocytogenes</i> (total)		4.3	3.0	26	18	57,848	39,583
Bacteria – toxin producing							
<i>Bacillus cereus</i>		10	10	60	60	195	195
<i>Clostridium perfringens</i>		28	28	164	164	164	164
<i>Staphylococcus aureus</i>		57	57	337	337	198	198
Viruses							
Norovirus		110	110	650	650	165	165
Rotavirus		70	70	414	414	268	268
Hepatitis A virus		1	1	4	4	1,515	1,515
Hepatitis E virus		0	0	1	1	4,545	4,545
Protozoa							
<i>Cryptosporidium</i> spp.		8	8	50	50	302	302
<i>Giardia</i> spp.		9	9	50	50	210	210
<i>Toxoplasma gondii</i> (congenital)		53	17	313	102	153,279	49,900
<i>Toxoplasma gondii</i> (acquired)		3	3	18	18	7,050	7,042
<i>Toxoplasma gondii</i> (total)		56	20	330	119	73,919	26,640
TOTAL		459	409	2,714	2,422		

^a costs are expressed in 2015 euros

Table 9. Attribution of the incidence, fatalities, disease burden and Cost-of-Illness to the major transmission pathways in the Netherlands, 2015*

Main pathway	Food	Environment	Human	Animal	Travel	Total
Incidence (per year)	657,478	193,657	564,825	79,607	129,100	1,624,667
Deaths (per year)	84	39	72	20	25	241
Disease burden (DALY)	5,767	2,664	2,246	1,021	1,139	12,838
Disease burden (DALY, discounted)	4,784	2,081	2,009	887	979	10,740
Cost of illness (M€, undiscounted) ^a	194	75	118	32	39	459
Cost of illness (M€, discounted at 4%) ^a	168	60	116	28	36	409

* due to the 14 pathogens included in this study

^a costs are expressed in 2015 euros

Table 10. Attribution of the incidence, fatalities, disease burden and Cost-of-Illness of foodborne disease* to food groups in the Netherlands, 2015

Food group	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Incidence (per year)	104,534	43,903	56,944	20,944	53,739	53,935	38,133	15,470	40,488	120,259	109,129	657,478
Deaths (per year)	9,1	9,1	17	4,8	7,6	8,1	6,0	2,0	3,4	5,4	12	84
Disease burden (DALY)	904	1,237	1,022	204	419	374	353	89	173	444	548	5,767
Disease burden (DALY, discounted)	726	881	892	185	360	321	292	81	161	413	471	4,784
Cost of illness (M€, undiscounted) ^a	29	27	27	7	16	14	12	4	9	26	25	194
Cost of illness (M€, discounted at 4%) ^a	24	16	24	6	14	13	10	4	9	25	23	168

* due to the 14 pathogens included in this study

^a costs are expressed in 2015 euros

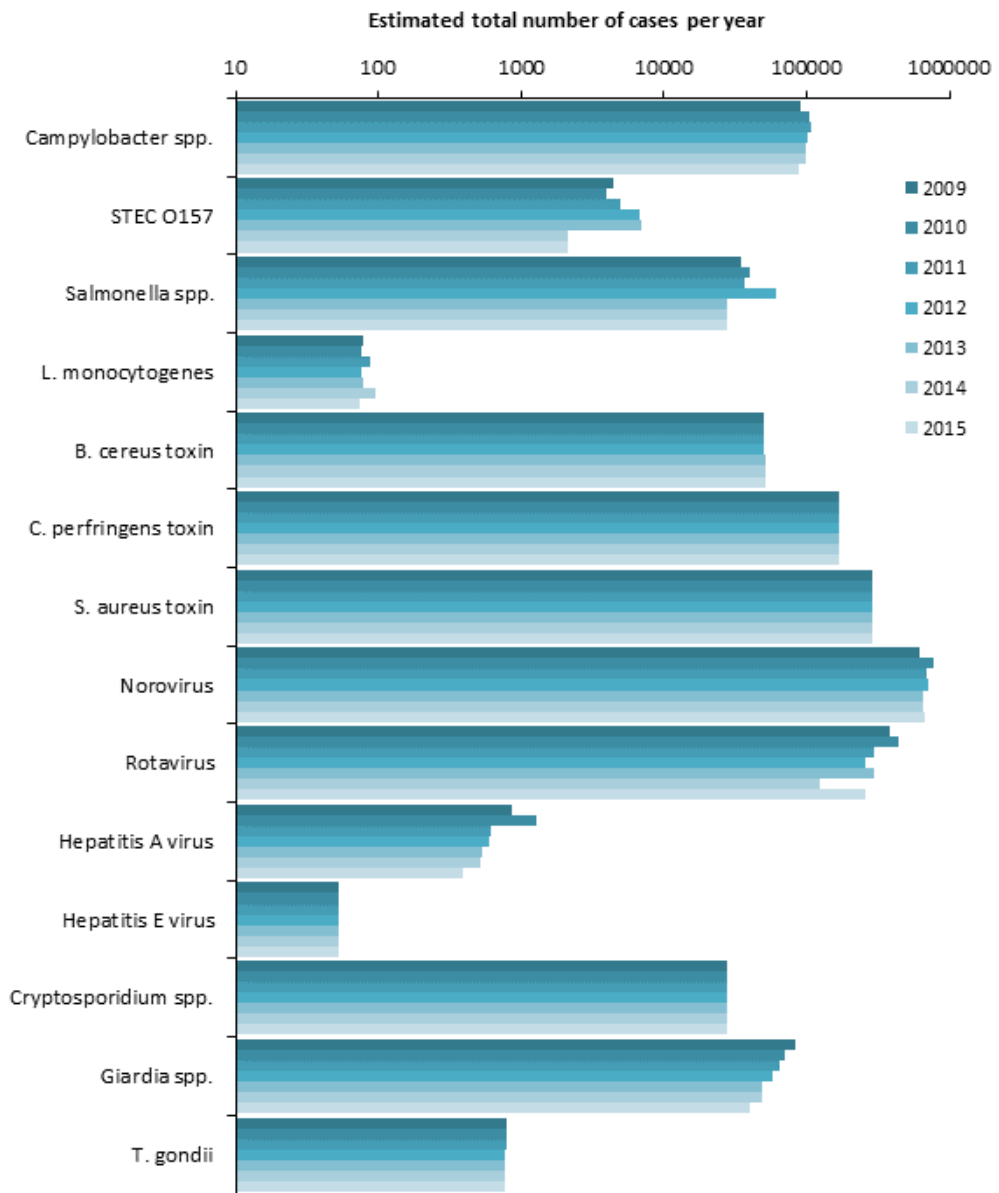


Figure 1. Comparison of incidence of food-related pathogens in 2009 through 2015.

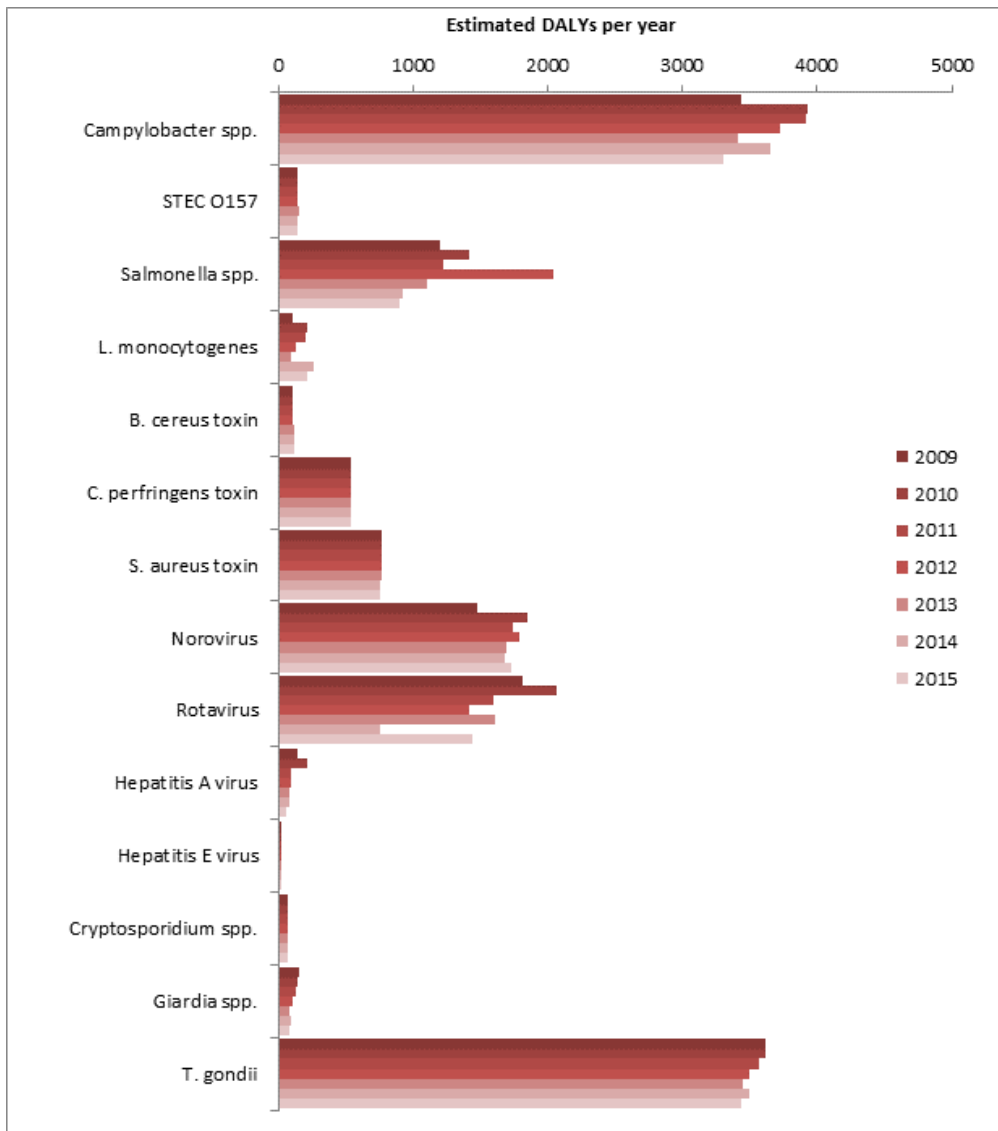


Figure 2. Comparison of disease burden of food-related pathogens in 2009 through 2015. DALYs are undiscount

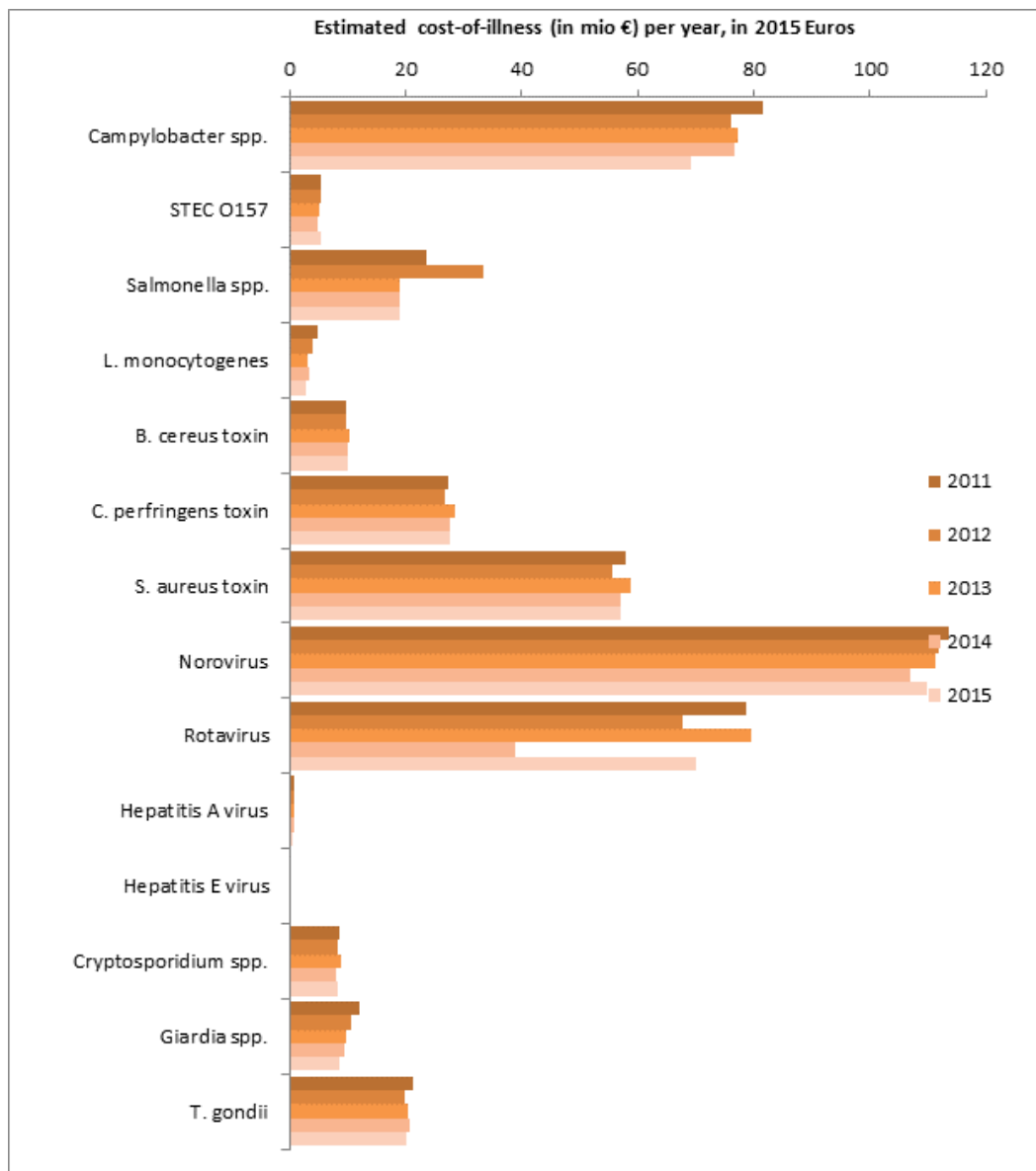


Figure 3. Comparison of discounted cost-of-illness^a (in million €) of food-related pathogens in 2011 through 2015. Costs are discounted with 4%.

^a costs are expressed in 2015 euros

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	88,437	54	3,305	75	69
STEC O157	2,119	4	138	11	5
L, monocytogenes	75	16	215	4	3
Salmonella	27,628	25	905	20	19
B. cereus toxine	51,884	0	118	10	10
C. perfringens toxine	168,959	5	541	28	28
S. aureus toxine	287,698	7	761	57	57
Hepatitis-A virus	393	1	65	1	1
Hepatitis-E virus	53	1	24	0	0
Norovirus	667,219	71	1,733	110	110
Rotavirus	261,024	42	1,440	70	70
C. parvum	27,806	2	71	8	8
G. lamblia	40,608	1	89	9	9
T. gondii	765	12	3,433	56	20
Total	1,624,667	241	12,838	459	409

* Note: Costs are expressed in 2015 euros

Attribution of incidence by pathogen to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter	37,143	18,218	5,572	16,891	10,612	88,437
STEC O157	856	365	216	434	248	2,119
L. monocytogenes	52	5	4	4	10	75
Salmonella	15,057	3,564	2,569	2,542	3,896	27,628
B. cereus toxine	46,332	571	623	571	3,788	51,884
C. perfringens toxine	152,739	3,717	3,548	3,548	5,407	168,959
S. aureus toxine	250,872	10,357	9,206	6,329	10,933	287,698
Hepatitis-A virus	45	44	72	0	233	393
Hepatitis-E virus	7	13	4	6	23	53
Norovirus	111,426	94,745	369,639	33,361	58,048	667,219
Rotavirus	33,933	44,374	151,655	7,831	23,231	261,024
C. parvum	3,309	7,702	7,619	3,726	5,450	27,806
G. lamblia	5,279	9,705	14,091	4,345	7,188	40,608
T. gondii	427	277	7	19	35	765
Total	657,478	193,657	564,825	79,607	129,100	1,624,667

Attribution of deaths by pathogen to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter	22.9	11.2	3.4	10.4	6.5	54.5
STEC O157	1.6	0.7	0.4	0.8	0.5	4.0
L. monocytogenes	11.1	1.1	0.8	0.9	2.1	16.0
Salmonella	13.8	3.3	2.3	2.3	3.6	25.2
B. cereus toxine	0.0	0.0	0.0	0.0	0.0	0.0
C. perfringens toxine	4.2	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	0.1	0.1	0.2	0.0	0.7	1.2
Hepatitis-E virus	0.1	0.2	0.0	0.1	0.3	0.6
Norovirus	11.8	10.0	39.1	3.5	6.1	70.5
Rotavirus	5.4	7.2	24.7	1.3	3.8	42.4
C. parvum	0.3	0.5	0.5	0.2	0.3	1.7
G. lamblia	0.2	0.3	0.4	0.1	0.2	1.2
T. gondii	6.8	4.4	0.1	0.3	0.6	12.1
Total	84.4	39.3	72.4	20.2	25.1	241.4

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

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter	1,388	681	208	631	397	3,305
STEC O157	56	24	14	28	16	138
L. monocytogenes	149	14	11	12	29	215
Salmonella	493	117	84	83	128	905
B. cereus toxine	105	1	1	1	9	118
C. perfringens toxine	489	12	11	11	17	541
S. aureus toxine	664	27	24	17	29	761
Hepatitis-A virus	7	7	12	0	38	65
Hepatitis-E virus	3	6	2	3	10	24
Norovirus	289	246	960	87	151	1,733
Rotavirus	187	245	837	43	128	1,440
C. parvum	8	20	19	10	14	71
G. lamblia	12	21	31	10	16	89
T. gondii	1,916	1,243	31	86	158	3,433
Total	5,767	2,664	2,246	1,021	1,139	12,838

Attribution of cost-of-illness (M€ per year, discounted at 4% and expressed in 2015 euros) to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter	29.1	14.3	4.4	13.2	8.3	69.4
STEC O157	2.2	0.9	0.6	1.1	0.6	5.5
L. monocytogenes	2.1	0.2	0.2	0.2	0.4	3.0
Salmonella	10.4	2.5	1.8	1.7	2.7	19.0
B. cereus toxine	9.1	0.1	0.1	0.1	0.7	10.1
C. perfringens toxine	25.0	0.6	0.6	0.6	0.9	27.6
S. aureus toxine	49.7	2.1	1.8	1.3	2.2	57.0
Hepatitis-A virus	0.1	0.1	0.1	0.0	0.4	0.6
Hepatitis-E virus	0.03	0.1	0.02	0.03	0.1	0.2
Norovirus	18.3	15.6	60.9	5.5	9.6	109.9
Rotavirus	9.1	11.9	40.7	2.1	6.2	70.0
C. parvum	1.0	2.3	2.3	1.1	1.6	8.4
G. lamblia	1.1	2.0	3.0	0.9	1.5	8.5
T. gondii	11.2	7.3	0.2	0.5	0.9	20.2
Total	168.4	59.9	116.5	28.4	36.1	409.3

Attribution of incidence by pathogen to food groups

Pathogen	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter	1,523	1,894	20,020	1,151	3,306	2,600	1,969	631	854	1,226	1,969	37,143
STEC O157	378	55	27	18	63	25	61	31	25	30	145	856
L. monocytogenes	6	5	3	2	13	9	4	1	3	3	3	52
Salmonella	1,897	2,153	2,228	3,343	994	617	949	467	647	903	858	15,057
B. cereus toxine	3,336	1,622	741	1,668	2,687	927	927	788	7,830	24,695	1,112	46,332
C. perfringens toxine	73,009	12,830	10,844	4,277	6,262	9,928	10,539	3,818	3,971	11,761	5,499	152,739
S. aureus toxine	18,815	20,321	19,568	8,279	36,878	14,551	5,017	4,516	18,815	74,258	29,854	250,872
Hepatitis-A virus	0	0	0	0	0	6	6	2	2	1	28	45
Hepatitis-E virus	0	5	0	0	0	0	1	0	0	0	1	7
Norovirus	3,566	3,454	3,231	2,117	2,229	17,271	8,134	3,454	5,794	5,571	56,604	111,426
Rotavirus	0	950	0	0	577	6,583	8,076	1,493	2,545	1,527	12,182	33,933
C. parvum	867	146	96	89	304	721	685	99	0	99	202	3,309
G. lamblia	1,040	253	164	0	406	681	1,742	169	0	174	649	5,279
T. gondii	98	214	20	0	20	16	25	0	0	10	24	427
Total	104,534	43,903	56,944	20,944	53,739	53,935	38,133	15,470	40,488	120,259	109,129	657,478

Attribution of deaths by pathogen to food groups

Pathogen	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter	0.9	1.2	12.3	0.7	2.0	1.6	1.2	0.4	0.5	0.8	1.2	22.9
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	1.2	1.0	0.7	0.4	2.7	2.0	0.8	0.3	0.7	0.6	0.5	11.1
Salmonella	1.7	2.0	2.0	3.1	0.9	0.6	0.9	0.4	0.6	0.8	0.8	13.8
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	0.4	0.3	0.1	0.2	0.3	0.3	0.1	0.1	0.3	0.2	4.2
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	0.1
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	0.4	0.3	0.2	0.2	1.8	0.9	0.4	0.6	0.6	6.0	11.8
Rotavirus	0.0	0.2	0.0	0.0	0.1	1.1	1.2	0.2	0.4	0.2	2.0	5.4
C. parvum	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
G. lamblia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
T. gondii	1.5	3.4	0.3	0.0	0.3	0.3	0.4	0.0	0.0	0.2	0.4	6.8
Total	9.1	9.1	16.7	4.8	7.6	8.1	6.0	2.0	3.4	5.4	12.2	84.4

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	56.9	70.8	748.1	43.0	123.5	97.2	73.6	23.6	31.9	45.8	73.6	1.388.1
STEC O157	24.6	3.6	1.7	1.2	4.1	1.6	4.0	2.0	1.6	2.0	9.4	55.9
L. monocytogenes	16.7	13.8	9.8	5.7	36.8	26.5	11.3	3.9	8.8	8.3	7.3	148.9
Salmonella	62.1	70.5	73.0	109.5	32.5	20.2	31.1	15.3	21.2	29.6	28.1	493.1
B. cereus toxine	7.6	3.7	1.7	3.8	6.1	2.1	2.1	1.8	17.8	56.2	2.5	105.4
C. perfringens toxine	233.6	41.1	34.7	13.7	20.0	31.8	33.7	12.2	12.7	37.6	17.6	488.8
S. aureus toxine	49.8	53.7	51.8	21.9	97.5	38.5	13.3	11.9	49.8	196.4	79.0	663.6
Hepatitis-A virus	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.3	0.3	0.2	4.6	7.4
Hepatitis-E virus	0.0	2.5	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.0	0.3	3.3
Norovirus	9.3	9.0	8.4	5.5	5.8	44.8	21.1	9.0	15.0	14.5	147.0	289.3
Rotavirus	0.0	5.2	0.0	0.0	3.2	36.3	44.6	8.2	14.0	8.4	67.2	187.3
C. parvum	2.2	0.4	0.2	0.2	0.8	1.8	1.8	0.3	0.0	0.3	0.5	8.5
G. lamblia	2.3	0.6	0.4	0.0	0.9	1.5	3.8	0.4	0.0	0.4	1.4	11.5
T. gondii	438.7	961.7	92.0	0.0	88.1	70.9	111.1	0.0	0.0	44.1	109.2	1.915.7
Total	903.8	1.236.5	1.021.8	204.4	419.4	374.3	352.6	89.0	173.2	443.7	547.8	5.766.7

Attribution of cost-of-illness (M€ per year, discounted at 4% and expressed in 2015 euros) to food groups

Pathogen	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter	1.2	1.5	15.7	0.9	2.6	2.0	1.5	0.5	0.7	1.0	1.5	29.1
STEC O157	1.0	0.1	0.1	0.0	0.2	0.1	0.2	0.1	0.1	0.1	0.4	2.2
L. monocytogenes	0.2	0.2	0.1	0.1	0.5	0.4	0.2	0.1	0.1	0.1	0.1	2.1
Salmonella	1.3	1.5	1.5	2.3	0.7	0.4	0.7	0.3	0.4	0.6	0.6	10.4
B. cereus toxine	0.7	0.3	0.1	0.3	0.5	0.2	0.2	0.2	1.5	4.8	0.2	9.1
C. perfringens toxine	11.9	2.1	1.8	0.7	1.0	1.6	1.7	0.6	0.6	1.9	0.9	25.0
S. aureus toxine	3.7	4.0	3.9	1.6	7.3	2.9	1.0	0.9	3.7	14.7	5.9	49.7
Hepatitis-A virus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Hepatitis-E virus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Norovirus	0.6	0.6	0.5	0.3	0.4	2.8	1.3	0.6	1.0	0.9	9.3	18.3
Rotavirus	0.0	0.3	0.0	0.0	0.2	1.8	2.2	0.4	0.7	0.4	3.3	9.1
C. parvum	0.3	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0	0.0	0.1	1.0
G. lamblia	0.2	0.1	0.0	0.0	0.1	0.1	0.4	0.0	0.0	0.0	0.1	1.1
T. gondii	2.6	5.6	0.5	0.0	0.5	0.4	0.7	0.0	0.0	0.3	0.6	11.2
Total	23.7	16.3	24.4	6.4	14.0	13.0	10.1	3.7	8.8	24.9	23.1	168.4

Attribution of disease burden (DALY per year, undiscounted) to food in the Netherlands from 2012 to 2015

Pathogen	Disease burden (DALY) per year - undiscounted			
	2012	2013	2014	2015
Toxoplasma gondii	1950	1930	1950	1920
Campylobacter spp.	1560	1430	1530	1390
Salmonella spp.	1350	600	500	490
S. aureus toxine	670	670	670	660
C. perfringens toxine	490	490	490	490
Norovirus	300	280	280	290
Rotavirus	185	210	100	190
B. cereus toxine	100	100	100	100
Listeria monocytogenes	90	60	180	150
STEC O157	57	60	60	60
Giardia spp.	14	13	13	12
Hepatitis-A virus	9	8	10	7
Cryptosporidium spp.	8	8	8	8
Hepatitis-E virus	2	2	3	3
Totaal	6780	5850	5890	5770

