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

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RIVM Letter report 2014-0115
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Synopsis

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 14,500 DALY in 2012 to 13,200 DALY in 2013. The share of foodborne transmission in this burden decreased from 6,600 to 5,800 DALY, reaching the lowest estimated level since 2009. The COI increased by 6 M€ compared to 2012, reaching a total of 424 million euro. The share of foodborne transmission was 172 million euro. The decrease in disease burden was a result of decreased incidences for most pathogens, except for rotavirus. The latter incidence increased by 16% compared to 2012, reaching a comparable level to 2011 and a ~30% lower level compared to 2009 and 2010.

The research presented in this report results in more insight in the true incidence of foodborne diseases and the associated disease burden and costs 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 2013

Het RIVM onderzoekt jaarlijks hoeveel mensen ziek worden van 14 ziekteverwekkers die via voedsel in het menselijk lichaam terechtkomen (darmpathogenen). Deze ziektelast 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 DALY's als gevolg van de 14 ziekteverwekkers daalde van ongeveer 6.600 in 2012 tot 5.800 DALY's in 2013.

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 bedroegen in 2013 172 miljoen euro.

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 ziektelast van alle 'routes' daalde ook, van 14.000 DALY in 2012 naar 13.200 DALY in 2013. De totale kosten werden geschat op 424 miljoen euro en waren daarmee vergelijkbaar met voorgaande jaren.

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

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

Contents

1 Introduction

Since 2008, RIVM regularly publishes estimates of the incidence, disease burden and costs of food-related disease on its web pages in the "Nationaal Kompas Volksgezondheid"[1]. 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]. Data in the latter paper referred to represent estimates for the year 2009, and updates based on data for the years 2010 up until 2012 have followed [2-4]. In this report, trend information from surveillance and demographic information was used to update the information to the year 2013.

The economical estimates of the disease burden, the cost-of-illness (COI) expressed in euros, were finalized for all 14 food-related pathogens for the year 2011 [5]. The economic models were added to the existing disease burden model. The estimates for 2011 [6] were updated to 2012 in a previous report [3], and the results for 2013 are integrated in this report.

[1] http://www.nationaalkompas.nl/gezondheidsdeterminanten/omgeving/milieu/voedselveiligheid/microbiologisch/

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 Netherlands[2].

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.: laboratory surveillance
- Non-typhoidal *Salmonella* spp.: laboratory surveillance
- Norovirus: hospitalisation for viral gastro-enteritis (ICD code 86)
- Rotavirus: laboratory surveillance
- Hepatitis A, and perinatal and acquired listeriosis: 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*), Shiga-toxin producing *Escherichia coli* O157 (STEC O157), hepatitis-E and toxoplasmosis.

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). Data for 2013 were not available in time due to changes in procedures at DHD and change in coding from ICD9 to ICD10. Therefore 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.

Excess mortality risks from campylobacteriosis and salmonellosis were assumed constant. 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.

2.2 Model updates

The estimation of excess mortality due to *Campylobacter* spp. and *Salmonella* spp. was updated. The initial model was based on a fixed

[2] http://statline.cbs.nl/statweb/, accessed November 12th 2014

number of reported cases, which was not updated annually. The updated model attributes the actual number of reported cases in the updating year over 5-year age classes. The proportions for attribution are estimates as five-year averages (2009-2013) from the age distribution in the surveillance data.

The effects of the updates on the burden estimation are shown by re-estimating the relevant results for all years from 2009-2012, as reported in Table 7. The interpretation of trends in this report are based on the results from the updated model.

2.3 Disease burden

The DALY calculations were not changed compared to previous years; hence all differences in the results for 2013 compared to 2011 and 2012 will reflect the impact of trends in the underlying information on demographics and pathogen incidence, and the aforementioned model updates. As described above, the impact of the latter is shown in Table 7.

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 2013 euros by multiplying all prices with the consumer price index for 2013 provided by Statistics Netherlands[3]. In order to allow comparison with earlier results we also updated the earlier cost-of-illness estimates (i.e, 2011 and 2012) to 2013 euros; hence all differences in the results for the year 2013 compared to 2011 and 2012 will reflect the impact of trends in the underlying information on demographics and pathogen incidence.

3 http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71311NED&D1=0&D2=0&D3=142,155,168,181,194,219,232,245&HDR=T&STB=G1,G2&VW=T, accessed November 12th, 2014

3 Results

3.1 Trend information

The number of inhabitants in the Netherlands slightly increased with 50,000 inhabitants in 2013 (Table 1). There was a decrease in all age classes except the ages 12-17 and 65+. The number of live births decreased by approximately 4,500 to 171,000 in 2013 (Table 2). A decrease was observed in all age classes (of mothers) except for mothers aged up to 19 years and aged between 35-39; both categories showed a slight increase. The number of stillbirths (24 weeks or more gestational age) in 2013 was 510, lower than the 594 cases reported for 2012. The number of hospitalizations for gastroenteritis remained fairly stable at 22,000.

Trend information for specific pathogens is presented in Table 3. A summary of trends (in comparison with 2012) is discussed below:

- The incidence of **campylobacteriosis** (laboratory confirmed cases) **decreased by 1%** from 48.8 to 48.0 cases per 100,000 inhabitants.
- The incidence of **salmonellosis** (laboratory confirmed cases) **decreased by 55%** from 20.7 to 9.3 per 100,000 inhabitants, reaching the lowest reported incidence rate since 1999 (the former lowest reported incidence rate was 11.6 per 100,000 in 2009).
- The incidence of gastroenteritis by **rotavirus** (laboratory confirmed cases) **increased further by 16%** from 20.1 to 23.3 cases per 100,000 inhabitants, reaching a comparable level to 2011 and a ~30% lower level compared to 2009 and 2010.
- The incidence of hospitalizations for viral gastroenteritis (a proxy for the **incidence of gastroenteritis by norovirus**) **decreased** from 19.7 to 18.6 cases per 100,000 inhabitants; the apparent increasing trend from 2001 onwards has levelled off in 2013.
- The incidence of **acquired listeriosis** (active surveillance) **increased** from 71 cases in 2012 to 76 cases in 2013. There were **7 fatalities**, similar to the 8 fatalities in 2012, but **considerably more** than the 4 fatalities in 2011. The statistical life expectancy of fatal cases was 13.7 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 **23%** (95% confidence interval 20-27%).
- The incidence of **perinatal listeriosis** (active surveillance) was 3 cases with no fatalities. The number of perinatal cases and mortality were **similar to previous years**.
- The incidence of diseases caused by **STEC O157** (active surveillance) was 90 with 36 hospitalizations (of 84 cases for which this information is known). The number of STEC O157 cases, including the number of hospitalized cases, was **higher than in previous years**. There were no fatal cases recorded.

The incidence of HUS cases was 7, the highest reported number since 2009.

- The incidence of **hepatitis A** (notified cases) **decreased** compared to the previous two years; the incidence was the lowest among the recorded incidences for the years 2006-2013. The number of **hospitalizations**, however, **increased**, with the proportion of hospitalized patients showing a continuous increase from 16.5% in 2009 to 27.5% in 2013. We have currently no explanation for this finding.

3.2 Disease incidence

The incidence of gastroenteritis by pathogen, of disease by non-gastrointestinal pathogens and of sequelae by pathogen in 2013 is presented in Tables 4-7, and Figure 1. There were increases in the incidence of *E. coli* O157, acquired listeriosis and rotavirus in the general population while the incidence of campylobacteriosis, salmonellosis, perinatal listeriosis, giardiasis, rotavirus and HAV decreased in comparison to 2012. The estimated incidence of the remaining pathogens was unchanged, mostly because no trend information was available. The estimated total number of foodborne cases due to the 14 pathogens decreased by approximately 40,000 to 1,680,000 in 2013 compared to 2012 and was at the lowest level since 2009. The total number of deaths for 2013 was 236 (in 2012 this was 265 as estimated with the updated model). Compared to 2012, the incidence of sequelae was similar (Table 6).

3.3 Disease burden by pathogen

The burden by pathogen is presented in Table 8 and Figure 2. The total burden of the 14 pathogens decreased by 800 DALY: from 14,000 DALY in 2012 to 13,200 DALY in 2013. The largest burden at population level was caused by *Toxoplasma gondii* and *Campylobacter* (both ~3,400 DALY), followed by norovirus and rotavirus (both ~1,600 DALY). *Salmonella* spp. ranked 5th with approximately 1,100 DALY. In general, estimates for 2013 were similar to the estimates for 2012, except for salmonellosis and listeriosis (both were lower in 2013). Perinatal listeriosis was the disease outcome with the highest individual burden among all pathogens (9.2 DALY per case), followed by congenital toxoplasmosis (6.3 DALY per case).

3.4 Cost of illness by pathogen

The total COI decreased with 10 M€ compared to 2012 and was estimated at 428 M€ (discounted at 4%) (Table 9). The three pathogens causing the largest discounted COI are norovirus (110 M€), rotavirus (78 M€) and *Campylobacter* spp. (76 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* (0.3 M€, discounted), followed by congenital *Toxoplasma gondii* infections (0.05 M€, discounted). The trends in COI compared to 2012 followed the trends in DALYs.

3.5 Attribution

The attribution results for DALYs and COI are presented in Tables 10 and 11. The foodborne disease burden decreased by 11% from 6,600 DALY to 5,900 DALY. All non-food routes decreased by 3-4% in DALYs

compared to 2012. Among the food pathway, all estimated DALYs decreased with 2-4% compared to 2012. 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 181 M€ to 174 M€. Approximately 40% of the COI was associated with meat and 50% with foods of animal origin. The COI for the other pathways similarly decreased except for the transmission among humans. The latter increased due to the increased rotavirus incidence.

3.6 Model update effects

Table 7 shows the effects of the model updates on the estimates for 2009-2012. The number of excess deaths due to campylobacteriosis increased by about 20 cases annually. The number of deaths due to salmonellosis fluctuated more compared to campylobacteriosis, with a peak in 2012 due to the *Salmonella* Thompson outbreak.

The overall DALY estimates increased by 300-500 DALY per year and the portion attributed to food by about 100-300 DALY per year. The estimated COI increased marginally by 1 M€ in 2011 and 5 M€ in 2012.

4 Discussion

The disease burden of 14 enteric pathogens decreased in 2013 by 1,300 DALY from 14,500 DALY in 2012 to 13,200 DALY. The share of foodborne transmission in this burden decreased by 700 DALY from 6,600 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 10 M€ to 428 (discounted at 4%), and the foodborne COI decreased by approximately 6 M€ to ~174 M€ compared to 2012. The decrease was a result of lower incidences for *Campylobacter* spp., *Salmonella* spp. and norovirus in 2013 compared to 2012.

The incidence of campylobacteriosis decreased in 2012 compared to 2011, after a continuously increasing trend from 2003 onwards, leading to a trend break. In 2013, the incidence decreased further. This trend break is possibly associated with the use of proton-pump-inhibitors [7, 8]. The refund policies of healthcare insurance companies for proton-pump inhibitors changed in 2012, possibly leading to lower intake and a lower proportion of individuals with an increased risk for campylobacteriosis in the population.

From August 2012 onwards, an increase in *Cryptosporidium* infections was observed in several EU countries, including the Netherlands, without a clear cause [9]. This increase in *Cryptosporidium* was not taken into account in the current disease burden estimates, as a constant incidence of cryptosporidiosis in the Netherlands is assumed for the model (based on laboratory surveillance data from 2001-2007). A rough estimate suggests that the disease burden for *Cryptosporidium* might have increased by a factor of 1.2, because a five-fold increase in cases was observed in 12 of 52 weeks (thus: 524/104×12/52=1.2). The data from the eight medical microbiological laboratories (available from at least 2010) might be useful for the annual trend update for *Cryptosporidium* and will be further examined for usability in future updates.

Other important aspects for interpreting results include the absence of trend information for bacterial toxins, toxoplasmosis and STEC O157, while 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 [10]. 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 care. For 2013 and 2014, laboratory surveillance data on Cryptosporidium have been collected by RIVM. The use of these data for trend updating will be explored further, and if appropriate, applied to the updated estimates over subsequent years. Initial explorations suggest that the incidence estimates based on laboratory surveillance are twice as high as extrapolated from surveillance data until 2007.

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Table 1. Population in the Netherlands by age group, 2009-13

Age group	2013	2012	2011	2010	2009
0	175,587	179,653	184,007	184,586	184,408
1-4	736,615	739,083	739,099	740,295	747,148
5-11	1,354,657	1,378,914	1,394,007	1,405,533	1,405,232
12-17	1,196,634	1,189,120	1,184,970	1,184,064	1,191,453
18-64	10,491,737	10,527,210	10,558,770	10,522,183	10,485,731
65+	2,824,345	2,716,368	2,594,946	2,538,328	2,471,815
Total	16,779,575	16,730,348	16,655,799	16,574,989	16,485,787

Table 2. Live births by age of mothers in the Netherlands, 2009-13

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

Table 3. Trends in incidence of food-related pathogens, 1999-2013

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

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

Table 4. Incidence of gastroenteritis by pathogen in the Netherlands, 2013 (population 16.8 million)

Pathogen	General population (x 1,000)	GP visit (x 1,000)	Hospitalised (x 1,000)	Fatal cases
All causes	4,809[†]	222	22.0	NA[#]
	3,988 - 5,716[‡]	72 - 513	-	
Bacteria – infectious				
Campylobacter spp.	100	24	1.1	55
	14 - 272	12 - 44	0.4 - 2.1	21 - 51
STEC O157	2.1	0.8	0.03	1
	0.2 – 8.8	0.02 - 3.1	-	0 - 1.2
Salmonella spp.	28	4.2	1.1	27
	2.4 - 85	2.3 - 7.1	0.5 - 2.1	30 - 39
Bacteria – toxin producing				
Bacillus cereus	51	7.0	0.2	0
	18 - 124	1.7 - 20	0.07 - 0.5	-
Clostridium perfringens	169	31	0.3	5
	56 - 375	7.4 - 81	0.01 - 0.6	0 - 19
Staphylococcus aureus	291	40	1.5	7
	124 - 548	11 - 96	0.6 - 2.8	0 - 28
Viruses				
Norovirus	663	16	1.9	66
	452 - 967	9.0 - 25	1.0 - 3.2	28 - 124
Rotavirus	298	18	5.8	47
	145 - 532	11.8 - 27.1	4.3 - 7.7	15 - 104
Protozoa				
Cryptosporidium spp.	28	1.7	0.6	2
	8.7 - 69.7	0.8 - 3.1	0.2 - 1.2	0 - 7.4
Giardia spp.	49	4.3	0.4	1
	24.7 - 94.9	2.2 - 7.6	0.04 - 1.4	0 - 5.4

[†] mean; [‡] 2.5-97.5 percentile; [#] not available

Table 5. Incidence of non-gastrointestinal pathogens in the Netherlands, 2013

Pathogen	Incidence	Fatal cases
Listeria monocytogenes[*]		
Perinatal	3	0
Acquired	76	7
Hepatitis A virus	535[†]	2
	(290 – 661)[‡]	(1 – 3)
Hepatitis E virus	53	1
	(8 – 33)	(0 – 1)
Toxoplasma gondii		
Congenital	349	12
	(179 – 610)	(7 – 21)
Acquired[**]	430	0
	(197 – 726)	

[*] No uncertainty because *Listeria* cases were acquired through active surveillance; [†] mean; [‡] 2.5-97.5 percentile; [**] chorioretinitis only

Table 6. Incidence of sequelae by pathogen in the Netherlands, 2013

Pathogen and sequelae	Incidence	Fatal cases
Campylobacter spp.		
Guillain-Barré Syndrome	148 (5 – 258)	1 (0 – 5)
Reactive arthritis	1,800 (768 - 3,667)	0
Irritable Bowel Syndrome	8,553 (2,466 - 22,317)	0
Inflammatory Bowel Disease	23 (16 – 31)	0
STEC O157		
Haemolytic Uremic Syndrome	22 (15 – 30)	2 (1 – 5)
End-Stage Renal Disease	3 (1 – 5)	1 (1 – 1)
Salmonella spp.		
Reactive arthritis	349 (123 – 728)	0
Irritable Bowel Syndrome	2,371 (349 - 7,162)	0
Inflammatory Bowel Disease	8 (6 – 11)	0
Listeria monocytogenes (perinatal)		
Meningitis	3*	NA
Neurological sequelae of meningitis	1 (1 – 2)	0
Listeria monocytogenes (acquired)		
Meningitis	18 (15 – 21)	NA
Neurological sequelae of meningitis	3 (1 – 4)	0
Toxoplasma gondii (congenital)		
Chorioretinitis 1st year of life	47 (24 – 84)	NA
Chorioretinitis later years of life	56 (29 – 99)	NA
Intracranial calcifications	37 (18 – 66)	NA
Hydrocephalus	7 (3 – 13)	NA
Central Nervous System Abnormalities	10 (2 – 28)	NA
Toxoplasma gondii (acquired)		
Chorioretinitis	426 (197 – 724)	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. Comparison of results from the original and updated model.

	Model	Year 2009	2010	2011	2012	2013
Deaths						
Campylobacter spp.	Original	38	39	34	34	
	Update	56	64	57	54	55
Salmonella spp.	Original	40	40	35	34	
	Update	38	45	35	59	27
Total number	Original	233	269	219	218	
	Update	250	300	240	270	240
DALYs						
Campylobacter spp.	Original	3,250	3,620	3,633	3,472	
	Update	3,434	3,926	3,922	3,720	3,408
Salmonella spp.	Original	1,270	1,410	1,294	1,796	
	Update	1,203	1,423	1,226	2,040	1,101
Total	Original	13,500	14,900	13,900	14,000	
	Update	13,900	15,400	14,200	14,500	13,300
Food	Original	5,800	6,400	6,200	6,500	
	Update	6,100	6,600	6,300	6,600	5,900
COI (M€ discounted at 4%)						
Campylobacter spp.	Original	n.a.	n.a.	76	73	
	Update	n.a.	n.a.	77	76	76
Salmonella spp.	Original	n.a.	n.a.	22	32	
	Update	n.a.	n.a.	22	34	19
Total	Original	n.a.	n.a.	416	412	
	Update	n.a.	n.a.	417	417	424
Food	Original	n.a.	n.a.	168	175	
	Update	n.a.	n.a.	169	180	172

Table 8. Estimated total DALY, DALY per 100,000 inhabitants and mean DALY per case of illness in the Netherlands, 2013

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						
Campylobacter spp.	3,408	3,041	20	18	34	31
STEC O157	138	109	0.8	0.7	65	51
Salmonella spp.	1,101	925	6.6	5.5	39	33
L. monocytogenes (perinatal)	28	16	0.2	0.1	9,194	5,467
L. monocytogenes (acquired)	64	61	0.4	0.4	844	809
L. monocytogenes (total)	92	77	0.5	0.5	1,161	986
Bacteria – toxin producing						
Bacillus cereus	116	116	0.7	0.7	2.3	2.3
Clostridium perfringens	541	534	3.2	3.2	3.2	3.2
Staphylococcus aureus	767	760	4.6	4.5	2.6	2.6
Viruses						
Norovirus	1,698	1,508	10	9.0	2.6	2.3
Rotavirus	1,605	1,440	10	8.6	5.4	4.8
Hepatitis A virus	86	74	0.5	0.4	161	139
Hepatitis E virus	23	20	0.1	0.1	434	377
Protozoa						
Cryptosporidium spp.	67	70	0.4	0.4	2.4	2.5
Giardia spp.	89	100	0.5	0.6	1.8	2.1
Toxoplasma gondii (congenital)	2,104	1,235	13	7.3	6,350	3,726
Toxoplasma gondii (acquired)	1,348	1,021	8.0	6.1	3,173	2,405
Toxoplasma gondii (total)	3,452	2,256	21	13	4,483	2,930

Table 9. Estimated total costs of illness (COI), COI per 100,000 inhabitants and mean COI per case of illness in the Netherlands, 2013

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						
Campylobacter spp.	82	76	489	455	824	767
STEC O157	5	2	31	14	2,449	1,076
Salmonella spp.	21	20	127	117	762	701
L. monocytogenes (perinatal)	2.8	1.0	17	6	947,107	328,672
L. monocytogenes (acquired)	2.4	2.2	14	13	31,196	29,252
L. monocytogenes (total)	5.2	3.2	31	19	65,977	40,622
Bacteria – toxin producing						
Bacillus cereus	10	10	60	60	197	197
Clostridium perfringens	28	28	167	167	166	166
Staphylococcus aureus	58	58	345	345	199	199
Viruses						
Norovirus	110	110	653	653	165	165
Rotavirus	78	78	467	467	263	263
Hepatitis A virus	1	1	5	5	1,535	1,535
Hepatitis E virus	0	0	1	1	4,576	4,576
Protozoa						
Cryptosporidium spp.	9	9	52	52	316	316
Giardia spp.	10	10	58	58	199	199
Toxoplasma gondii (congenital)	53	17	314	102	153,698	50,070
Toxoplasma gondii (acquired)	3.0	3	18	18	7,104	7,095
Toxoplasma gondii (total)	56	20	332	120	72,405	26,217
TOTAL	**472**	**424**	**2,814**	**2,526**		

[a] costs are expressed in 2013 euros

Table 10. Attribution of the incidence, fatalities, disease burden and Cost-of-Illness[*] to the major transmission pathways in the Netherlands, 2013

Main pathway	Food	Environment	Human	Animal	Travel	Total
Incidence (per year)	669,579	203,682	587,588	83,578	134,974	1,679,402
Deaths (per year)	79	39	73	20	25	236
Disease burden (DALY)	5,847	2,739	2,349	1,057	1,191	13,183
Disease burden (DALY, discounted)	4,857	2,142	2,092	917	1,022	11,030
Cost of illness (M€, undiscounted)[a]	198	78	123	32	41	472
Cost of illness (M€, discounted at 4%)[a]	172	63	122	29	38	424

[*] due to the 14 pathogens included in this study
[a] costs are expressed in 2013 euros

Table 11. Attribution of the incidence, fatalities, disease burden and Cost-of-Illness of foodborne disease[*] to food groups in the Netherlands, 2013

Food group	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Incidence (per year)	105,015	44,532	59,697	21,193	54,711	55,351	39,850	15,812	41,048	121,225	111,144	669,579
Deaths (per year)	8.4	8.7	16	4.7	6.1	7.0	5.8	1.9	3.1	5.1	12	79
Disease burden (DALY)	907	1,252	1,056	225	410	368	358	91	177	447	557	5,847
Disease burden (DALY, discounted)	729	892	923	200	354	319	298	83	163	415	480	4,857
Cost of illness (M€, undiscounted)[a]	29	27	29	6.8	16	15	12	3.9	9.2	26	25	198
Cost of illness (M€, discounted at 4%)[a]	23	17	26	6.4	14	13	11	3.7	9.0	25	24	172

[*] due to the 14 pathogens included in this study

[a] costs are expressed in 2013 euros

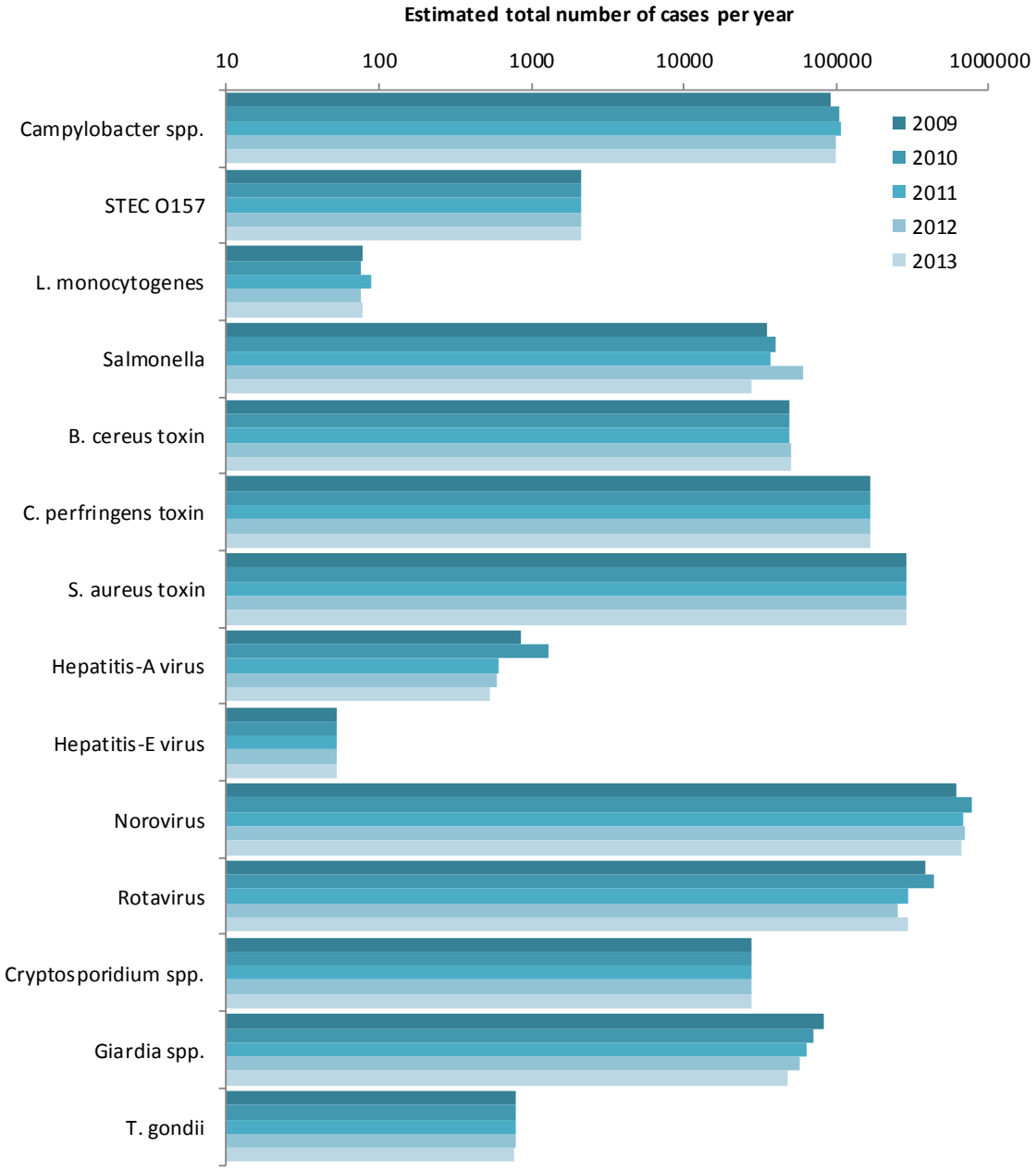

Figure 1. Comparison of incidence of food-related pathogens in 2009 through 2013.

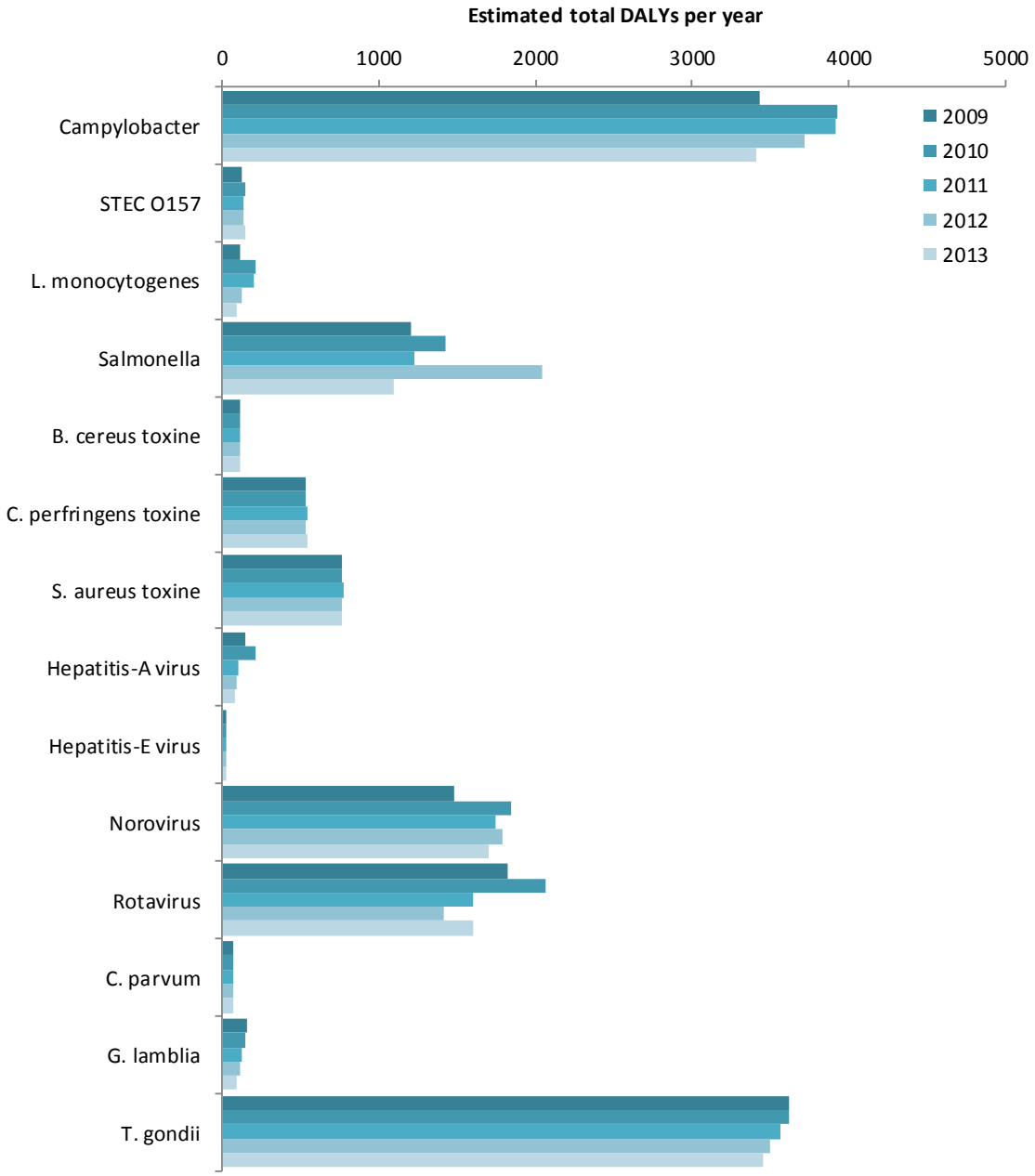

Figure 2. Comparison of disease burden of food-related pathogens in 2009 through 2013.

Annex. Detailed results

Summary of results

Pathogen	Incidence (per year)	Deaths (per year)	DALY (undisc.)	Costs (M€ per year)* Undisc.	Disc. 4%
Campylobacter spp.	99,501	55	3,408	83	76
STEC O157	2,141	4	138	5	2
L. monocytogenes	79	7	92	5	3
Salmonella spp.	28,019	27	1,101	20	19
B. cereus toxine	51,329	0	116	10	10
C. perfringens toxine	168,703	5	541	28	28
S. aureus toxine	291,077	7	767	58	58
Hepatitis-A virus	534	2	86	1	1
Hepatitis-E virus	53	1	23	0.2	0.2
Norovirus	663,274	66	1,698	110	110
Rotavirus	297,538	47	1,605	78	78
C. parvum	27,689	2	67	9	9
G. lamblia	48,695	1	89	10	10
T. gondii	770	12	3,452	56	20
Totaal	1,679,402	236	13,183	472	424

* *Note: Costs are expressed in 2013 euros.*

Attribution of incidence by pathogen to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	41,789	20,498	6,269	19,005	11,940	99,501
STEC O157	865	368	218	439	250	2,141
L. monocytogenes	55	5	4	4	11	79
Salmonella spp.	15,270	3,614	2,606	2,578	3,951	28,019
B. cereus toxine	45,836	565	616	565	3,747	51,329
C. perfringens toxine	152,508	3,711	3,543	3,543	5,398	168,703
S. aureus toxine	253,819	10,479	9,314	6,404	11,061	291,077
Hepatitis-A virus	62	59	97	0	316	534
Hepatitis-E virus	7	13	4	6	23	53
Norovirus	110,595	94,214	367,568	33,174	57,723	663,274
Rotavirus	38,681	50,581	172,869	8,926	26,481	297,538
C. parvum	3,330	7,659	7,576	3,705	5,419	27,689
G. lamblia	6,331	11,638	16,897	5,210	8,619	48,695
T. gondii	431	278	7	19	35	770
Total	669,579	203,682	587,588	83,578	134,974	1,679,402

Attribution of deaths by pathogen to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Totaal
Campylobacter spp.	23.2	11.4	3.5	10.5	6.6	55.2
STEC O157	1.6	0.7	0.4	0.8	0.5	4.0
L. monocytogenes	4.8	0.5	0.4	0.4	0.9	7.0
Salmonella spp.	14.5	3.4	2.5	2.5	3.8	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	4.5
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	1.7
Hepatitis-E virus	0.1	0.2	0.0	0.1	0.3	0.6
Norovirus	11.1	9.4	36.9	3.3	5.8	66.5
Rotavirus	6.1	8.0	27.4	1.4	4.2	47.1
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	6.8	4.4	0.1	0.3	0.6	12.2
Total	79.1	39.3	72.7	19.9	24.6	235.6

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

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	1,431	702	215	651	409	3,408
STEC O157	56	24	14	28	16	138
L. monocytogenes	64	6	5	5	12	92
Salmonella spp.	601	142	102	101	155	1,101
B. cereus toxine	104	1	1	1	9	116
C. perfringens toxine	490	12	11	11	17	541
S. aureus toxine	668	28	25	17	29	767
Hepatitis-A virus	8	10	16	0	52	86
Hepatitis-E virus	2	6	2	3	10	23
Norovirus	284	241	940	85	148	1,698
Rotavirus	209	273	932	48	143	1,605
C. parvum	3	20	20	10	14	67
G. lamblia	1	24	35	11	18	89
T. gondii	1,926	1,250	31	86	159	3,452
Total	5,847	2,739	2,349	1,057	1,191	13,183

Attribution of cost-of-illness (k€ per year, undiscounted and expressed in 2013 euros) to main pathways

Pathogen	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	34,662	17,001	5,199	15,763	9,903	82,528
STEC O157	2,118	902	535	1,075	613	5,243
L. monocytogenes	3,607	349	276	281	698	5,212
Salmonella spp.	10,909	2,582	1,862	1,842	2,822	20,017
B. cereus toxine	9,045	111	122	111	739	10,129
C. perfringens toxine	25,290	615	587	587	895	27,976
S. aureus toxine	50,515	2,085	1,854	1,274	2,201	57,930
Hepatitis-A virus	93	91	149	0	486	820
Hepatitis-E virus	33	60	18	26	104	243
Norovirus	18,294	15,555	60,687	5,477	9,530	109,543
Rotavirus	10,182	13,315	45,508	2,350	6,971	78,326
C. parvum	1,040	2,420	2,394	1,171	1,712	8,737
G. lamblia	1,258	2,313	3,358	1,035	1,713	9,676
T. gondii	31,109	20,182	502	1,394	2,565	55,752
Total	198,156	77,583	123,050	32,387	40,955	472,131

Attribution of cost-of-illness (k€ per year, discounted at 4% and expressed in 2013 euros) to main pathways

Pathogen	**Food**	**Environment**	**Human**	**Animal**	**Travel**	**Total**
Campylobacter spp.	31,946	15,669	4,792	14,528	9,127	76,061
STEC O157	930	396	235	472	269	2,303
L. monocytogenes	2,219	215	170	173	430	3,207
Salmonella	10,220	2,419	1,744	1,725	2,644	18,753
B. cereus toxine	9,045	111	122	111	739	10,129
C. perfringens toxine	25,290	615	587	587	895	27,976
S. aureus toxine	50,515	2,085	1,854	1,274	2,201	57,930
Hepatitis-A virus	93	91	149	0	486	820
Hepatitis-E virus	33	60	18	26	104	243
Norovirus	18,294	15,555	60,687	5,477	9,530	109,543
Rotavirus	10,182	13,315	45,508	2,350	6,971	78,326
C. parvum	1,040	2,420	2,394	1,171	1,712	8,737
G. lamblia	1,258	2,313	3,358	1,035	1,713	9,676
T. gondii	11,264	7,308	182	505	929	20,187
Total	172,331	62,573	121,799	29,435	37,752	423,890

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 spp.	1713	2131	22526	1296	3719	2925	2215	710	961	1379	2215	41789
STEC O157	381	55	27	18	64	25	61	31	25	30	146	865
L. monocytogenes	6	5	4	2	14	10	4	1	3	3	3	55
Salmonella spp.	1924	2184	2260	3390	1008	626	962	473	657	916	870	15270
B. cereus toxine	3300	1604	733	1650	2659	917	917	779	7746	24431	1100	45836
C. perfringens toxine	72899	12811	10828	4270	6253	9913	10523	3813	3965	11743	5490	152508
S. aureus toxine	19036	20559	19798	8376	37311	14722	5076	4569	19036	75131	30205	253819
Hepatitis-A virus	0	0	0	0	0	8	8	3	3	2	38	62
Hepatitis-E virus	0	5	0	0	0	0	1	0	0	0	1	7
Norovirus	3539	3428	3207	2101	2212	17142	8074	3428	5751	5530	56183	110595
Rotavirus	0	1083	0	0	658	7504	9206	1702	2901	1741	13886	38681
C. parvum	872	147	97	90	306	726	689	100	0	100	203	3330
G. lamblia	1247	304	196	0	487	817	2089	203	0	209	779	6331
T. gondii	98	216	21	0	20	16	25	0	0	10	25	431
Total	105015	44532	59697	21193	54711	55351	39850	15812	41048	121225	111144	669579

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 spp.	1.0	1.2	12.5	0.7	2.1	1.6	1.2	0.4	0.5	0.8	1.2	23.2
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	0.5	0.5	0.3	0.2	1.2	0.9	0.4	0.1	0.3	0.3	0.2	4.8
Salmonella spp.	1.8	2.1	2.1	3.2	1.0	0.6	0.9	0.5	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	1.9	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	5.6	11.1
Rotavirus	0.0	0.2	0.0	0.0	0.1	1.2	1.5	0.3	0.5	0.3	2.2	6.1
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	3.4	0.3	0.0	0.3	0.3	0.4	0.0	0.0	0.2	0.4	6.8
Total	8.4	8.7	16.5	4.7	6.1	7.0	5.8	1.9	3.1	5.1	11.8	79.1

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 spp.	59	73	772	44	127	100	76	24	33	47	76	1,431
STEC O157	25	4	2	1	4	2	4	2	2	2	9	56
L. monocytogenes	7	6	4	2	16	11	5	2	4	4	3	64
Salmonella spp.	75	86	89	133	40	25	38	19	26	36	34	601
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	490
S. aureus toxine	50	54	52	22	98	39	13	12	50	198	80	668
Hepatitis-A virus	0	0	0	0	0	1	1	0	0	0	6	8
Hepatitis-E virus	0	2	0	0	0	0	0	0	0	0	0	2
Norovirus	9	9	8	5	6	44	21	9	15	14	144	284
Rotavirus	0	6	0	0	4	40	50	9	16	9	75	209
C. parvum	1	0	0	0	0	1	1	0	0	0	0	3
G. lamblia	0	0	0	0	0	0	1	0	0	0	0	1
T. gondii	441	967	92	0	89	71	112	0	0	44	110	1,926
Total	907	1252	1056	225	410	368	358	91	177	447	557	5847

Attribution of cost-of-illness (k€ per year, undiscounted and expressed in 2013 euros) to food groups

Pathogen	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish & shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	1,421	1,768	18,683	1,075	3,085	2,426	1,837	589	797	1,144	1,837	34,662
STEC O157	934	136	66	44	157	61	150	76	61	74	358	2,118
L. monocytogenes	404	335	238	137	891	642	274	94	213	202	177	3,607
Salmonella spp.	1,375	1,560	1,615	2,422	720	447	687	338	469	655	622	10,909
B. cereus toxine	651	317	145	326	525	181	181	154	1,529	4,821	217	9,045
C. perfringens toxine	12,089	2,124	1,796	708	1,037	1,644	1,745	632	658	1,947	910	25,290
S. aureus toxine	3,789	4,092	3,940	1,667	7,426	2,930	1,010	909	3,789	14,952	6,011	50,515
Hepatitis-A virus	0	0	0	0	0	12	12	4.1	4.1	2.9	59	93
Hepatitis-E virus	0	25	0	0	0	2	2	1	0	0	3	33
Norovirus	585	567	531	348	366	2,836	1,335	567	951	915	9,293	18,294
Rotavirus	0	285	0	0	173	1,975	2,423	448	764	458	3,655	10,182
C. parvum	272	46	30	28	96	227	215	31	0	31	63	1,040
G. lamblia	248	60	39	0	97	162	415	40	0	42	155	1,258
T. gondii	7,124	15,617	1,493	0	1,431	1,151	1,804	0	0	716	1,773	31,109
Total	28,892	26,931	28,574	6,754	16,002	14,696	12,093	3,885	9,234	25,959	25,135	198,156

Attribution of cost-of-illness (k€ per year, discounted at 4% and expressed in 2013 euros) to food groups

Pathogen	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish & shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	1,310	1,629	17,219	990	2,843	2,236	1,693	543	735	1,054	1,693	31,946
STEC O157	410	60	29	20	69	27	66	33	27	33	157	930
L. monocytogenes	249	206	146	84	548	395	169	58	131	124	109	2,219
Salmonella spp.	1,288	1,461	1,513	2,269	675	419	644	317	439	613	583	10,220
B. cereus toxine	651	317	145	326	525	181	181	154	1,529	4,821	217	9,045
C. perfringens toxine	12,089	2,124	1,796	708	1,037	1,644	1,745	632	658	1,947	910	25,290
S. aureus toxine	3,789	4,092	3,940	1,667	7,426	2,930	1,010	909	3,789	14,952	6,011	50,515
Hepatitis-A virus	0	0	0	0	0	12	12	4.1	4.1	2.9	59	93
Hepatitis-E virus	0	25	0	0	0	1.6	2.5	1.2	0.0	0.0	3.4	33
Norovirus	585	567	531	348	366	2,836	1,335	567	951	915	9,293	18,294
Rotavirus	0	285	0	0	173	1,975	2,423	448	764	458	3,655	10,182
C. parvum	272	46	30	28	96	227	215	31	0	31	63	1,040
G. lamblia	248	60	39	0	97	162	415	40	0	42	155	1,258
T. gondii	2,580	5,655	541	0	518	417	653	0	0	259	642	11,264
Total	23,470	16,527	25,927	6,439	14,372	13,462	10,565	3,738	9,026	25,253	23,551	172,331

RIVM
Committed to *health and sustainability*