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

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RIVM Letter report 2017-0097
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Colophon

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Synopsis

Disease burden of food-related pathogens in the Netherlands, 2016

The Ministry of VWS has requested RIVM to present an annual update on the number of illnesses, disease burden and cost-of-illness 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 unit. Furthermore, the cost-of-illness (COI) related to the 14 food-related pathogens was estimated and expressed in euros. The COI estimate includes healthcare costs, the costs for the patient and / or his family, such as travel expenses, as well as costs in other sectors, for example due to productivity losses. The total disease burden caused by the 14 pathogens decreased slightly from around 12,190 DALYs in 2015 to 12,020 DALYs in 2016. The share of foodborne transmission in this estimated burden was comparable to earlier years, mounting to 4,708 DALYs in 2016. The total COI caused by the 14 pathogens decreased slightly from 435 €M in 2015 to 430 €M in 2016. The food-related COI was with 171 M€ in 2016, which is slightly lower than in 2015 (i.e. 172 €M). The differences in DALYs and COI between 2015 and 2016 are largely due to fluctuations in the type of infections that occur, the burden of disease they cause and the varying costs per infection.

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-illness and enables researchers and policy-makers to monitor trends in time for these 14 pathogens.

Keywords: food-related disease, disease burden, DALY, cost-of-illness, costs, trend

Publiekssamenvatting

Ziektelast van via voedsel overdraagbare ziekteverwekkers in Nederland in 2016

Het RIVM onderzoekt jaarlijks hoeveel mensen ziek worden van 14 ziekteverwekkers die via voedsel in het menselijk lichaam terechtkomen (darmpathogenen). Deze voedsel-gerelateerde ziektelast wordt uitgedrukt in DALY's (Disability Adjusted Life Year), een internationaal gehanteerde maat voor het aantal gezonde levensjaren dat verloren gaat aan ziekte of vroegtijdig? overlijden. Het aantal DALY's als gevolg van de 14 ziekteverwekkers is in 2016 geschat op 4.708, en is daarmee iets hoger dan in 2015 (4.642 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 kosten die verbonden zijn aan de 14 ziekteverwekkers die mensen via voedsel opliepen bedroegen 171 miljoen euro. Dit is evenveel als de kosten in 2015 (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. Het verschilt per ziekteverwekker hoe groot het aandeel in de blootstellingsroute is. De totale ziektelast van alle 'routes' is geschat op 12.020 DALY's, en is daarmee iets lager dan in 2015 (12.190 DALY's). De totale kosten zijn geschat op 430 miljoen euro en waren daarmee iets lager dan in 2015 (435 miljoen). De verschillen in DALY's en kosten zijn grotendeels een gevolg van schommelingen in het aantal infecties dat de 14 ziekteverwekkers veroorzaakten, net als de daaruit volgende ziektelast en kosten.

Het ministerie van VWS is de opdrachtgever van dit onderzoek. De resultaten bieden handvatten om meer zicht te krijgen op het daadwerkelijker aantal voedselinfecties dat mensen jaarlijks oplopen, de bijbehorende ziektelast en de blootstellingsroutes.

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-illnesses of food-related disease on its web pages[1] and since 2010 in publicly available reports (e.g. [1-6]).

The health impact of food-related disease is expressed in Disability Adjusted Life Years (DALY) and cost-of-illness (COI). The methodology that is used to estimate the DALYs is described in detail in a peer-reviewed paper [7]. The COI is expressed in euros for all 14 food-related pathogens was calculated for the first time in 2011 [8]. The economic module was subsequently integrated to the existing disease burden model, and annual updates of both, disease burden and COI have followed [1-6].

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) were used to update the information to the year 2016. And in contrast to previous estimates [1-8], we used available RIVM laboratory surveillance for Hepatitis-E virus and *Cryptosporidum* spp., no negative trend correction for *Giardia* spp., newly available European disability weights by Haagsma et al. [9] and recent life tables, when updating DALY and COI estimates for the year 2012 until 2016 and presented in the current report.

[1] https://www.staatvenz.nl/kerncijfers/voedselinfecties-aantal-verloren-gezonde-levensjaren

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].

Table 1. Population in the Netherlands by age group, 2012-2016

Age group	2016	2015	2014	2013	2012
0	170,341	174,681	170,953	175,587	179,653
1-4	706,513	713,641	726,716	736,615	739,083
5-11	1,313,978	1,324,894	1,338,448	1,354,657	1,378,914
12-17	1,225,749	1,215,977	1,206,685	1,196,634	1,189,120
18-64	10,477,231	10,463,848	10,467,463	10,491,7378	10,527,210
65+	3,085,308	3,007,685	2,919,024	2,824,345	2,716,368
Total	16,979,120	16,900,726	16,829,289	16,779,575	16,730,348

Table 2. Live births by age of mothers in the Netherlands, 2012-2016

Age of mother	2016*	2015	2014	2013	2012
-19	1,104	1,109	1,276	1,360	1,592
20-24	13,363	13,125	14,213	14,581	15,206
25-29	49,266	48,724	50,307	49,342	50,371
30-34	66,303	66,373	68,120	65,925	67,489
35-39	33,237	34,070	33,797	32,939	33,725
40-44	6,740	6,733	7,046	6,836	7,212
45+	397	376	422	358	364
Total	170,410	170,510	175,181	171,341	175,959

* Estimates based on observed trend from 2011-2015

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): mandatory notification and active laboratory surveillance;
- Norovirus: estimated norovirus-associated hospitalized cases derived from RIVM laboratory surveillance;
- Rotavirus: RIVM laboratory surveillance;
- Hepatitis-A virus and perinatal and acquired listeriosis: mandatory notification and active laboratory surveillance;
- Hepatitis-E virus*:* RIVM laboratory surveillance data; Note this is different with earlier reports [1-8] where a stable incidence based on Borgen et al.[10] was assumed.
- *Cryptosporidium* spp.: RIVM laboratory surveillance data since 2013. Note this is different with earlier reports [1-8] where a stable incidence was assumed since 2003.
- *Giardia* spp.: a stable incidence was assumed since 2007 (i.e. the last year of RIVM laboratory surveillance data for *Giardia* spp.).

[2] http://statline.cbs.nl/Statweb; accessed March 14th 2017

Note this is different with earlier reports [1-8] where 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 *Stapylococcus aureus*), and toxoplasmosis. For the latter, trends in reported fatalities are included.

Trends in hospitalizations for gastro-enteritis as primary case (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. Since 2015 the number of hospitalized patients are indirectly estimated from the observed time series of RIVM laboratory surveillance data (i.e. primarily tested faeces) of rotavirus, norovirus, campylobacteriosis and salmonellosis.

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 Disease burden

The disease burden estimates were updated by using more recent life expectancy tables from the Global burden of disease (GBD) 2010 study[11] and newly available European disability weights by Haagsma et al. [9].

The life expectancy table as determined for the GBD 2010 study[11] is the projected frontier remaining life expectancy in 2050 per age group, whereby equal life expectancies are assumed for men and women. In the previous reports and papers [1-8] the life expectancy tables determined for the GBD 1990 study were used with different life expectancies for men and women. In Table A.1 in Annex I, old and new life tables are presented.

A further applied adaptation is the use of the newly available European disability weights by Haagsma et al. [9]. Contrary to the earlier disability weights, which were derived from several studies using various methodologies were these disability weights derived from a single study using a survey of 30,660 European citizens (one-quart of them being Dutch), who had to rank health states using a systematic developed for the GBD 2010 study. These disability weights were incorporated in the disease burden model. The selection of the different disability weights per health state was discussed with experts at RIVM. A full overview of the updated disability weights and durations is presented in Table A.2 in Annex I.

2.3 Cost of illness

Contrary to earlier estimates [1-6, 8] we used the newly available reference prices for health economic evaluations from the Dutch healthcare institute [12, 13]. And in order to better reflect the current situation of the labour market, and following the most recent guideline [12, 13], the friction period (i.e. the period needed to replace a sick, invalid or dead worker) was changed from 23 weeks [14] to 12 weeks [12, 13]. The previous references prices and friction period were from 2009 [14], for full details see Table A.3 in Annex I.

All costs were expressed in 2016 euros using Dutch consumer price indices as provided by Statistics Netherlands[3], where necessary.

[3] http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71905ned&D1=a&D2=0,95-115&HDR=T&STB=G1&VW=T

3 Results

3.1 Trend information

Trend information for specific pathogens is presented in Table 3. A summary of trends (in comparison with 2015) is discussed below:

- The incidence of campylobacteriosis (laboratory confirmed cases) decreased from 42.8 to 38.3 cases per 100,000 inhabitants, showing a continuously decreasing trend since 2011.
- The incidence of salmonellosis (laboratory confirmed cases) is with 10.7 cases per 100,000 inhabitants slightly higher than in 2015 (9.0 per 100,000 inhabitants), an increase mainly due to the European outbreak of *Salmonella* Enteritidis in eggs[15].
- The incidence of cryptosporidiosis (laboratory confirmed cases) is increasing since the start of the surveillance in 2013 and was in 2016 12.4 per 100,000 inhabitants compared to 10.5 per 100,000 inhabitants in 2015.
- The incidence of gastroenteritis by rotavirus (laboratory confirmed cases) was 10.5 per 100,000 inhabitants, which is about half of the cases in 2015 (20.4 per 100,000 inhabitants), but similar to the number of cases reported in 2014 (9.3 per 100,000 inhabitants).
- The incidence of gastroenteritis by norovirus (laboratory confirmed cases) was with 32.2 cases per 100,000 inhabitants higher than in earlier years (e.g. 26.5 per 100,000 inhabitants in 2015).
- The incidence of acquired listeriosis (laboratory confirmed cases, active surveillance) increased from 72 cases in 2015 to 89 cases in 2016, and was similar to 2014 (92 cases). However, the recorded fatalities decreased markedly from 15 in 2015 to 8 in 2016, and were similar to earlier years (i.e. 2012-2014).
- In 2016 the incidence of perinatal listeriosis (laboratory confirmed cases, active surveillance) was 7 cases with 4 fatalities. This was the highest number of fatalities so far ever recorded. Higher incidences were only reported in 2011 (9 laboratory confirmed cases).
- The incidence of diseases caused by STEC O157 (laboratory confirmed cases, active surveillance) was 64 laboratory confirmed cases with 21 hospitalized cases (of 60 cases for which this information is known). The number of STEC O157 cases, including the number of hospitalized cases, is slightly lower than in previous years (76 cases and 27 hospitalized cases in 2015). The incidence of HUS cases was with 3 in 2016 similar to 2015.
- The incidence of hepatitis-A virus (notified cases) was 81 reported cases and 22 hospitalized cases. These numbers are similar to those in 2015 (80 reported cases and 23 hospitalized cases).
- With 3.1 cases per 100,000 inhabitants was the incidence of hepatitis-E virus (laboratory confirmed cases) similar to 2015, but higher than in 2014 (2.2 cases per 100,000 inhabitants) or in 2013 (0.9 cases per 100,000 inhabitants).

- The number of patients that were admitted to hospital due to GE was estimated to be 20,796 in 2016, and therefore slightly lower than in 2015 (22,064), but similar to 2014 (20,345). The observed decrease in 2016 was mainly driven by the far lower number of rotavirus infections in 2016 compared to 2015.

Table 3. Trends in incidence per 100,000 inhabitants of food-related pathogens, 1999-2016

Year	Ca[a]	Sa[a]	Cryp[a]	RV[a]	NV[a]	aLm[b]	aLm fata[b]	pLm[b]	pLm fatal[b]	O157[b]	O157 hosp[b]	HAV[b]	HAV hosp[b]	HEV[a]
1999	38.7	21.1		19.2	14.2					32				
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	23.1	73	13	4	1	51	21	262	52	0.8
2011	51.3	12.2		23.7	21.0	79	4	9	1	65	18[d]	125	25	0.9
2012	48.8	20.7		20.1	26.3[c]	71	8	6	0	85	31[e]	121	28	1.0
2013	48.0	9.3	5.8	23.3	25.8[c]	76	7	3	0	90	36[f]	109	30	0.9
2014	47.54	9.2	5.9	9.45	25.3[c]	92	9	4	2	79	31[g]	105	23	2.2
2015	42.80	9.0	10.5	20.4	26.5[c]	69	15	3	1	76	27[h]	80	23	3.1
2016	38.31	10.7	12.4	10.5	32.9[c]	89	8	7	4	64	21[i]	81	22	3.1

Used abbreviations:

Ca: *Campylobacter* spp. ; Sa: *Salmonella* spp.; Cryp: *Cryptosporidium* spp.; RV: rotavirus; NV: norovirus; aLm: acquired listeriosis; pLm: perinatal listeriosis: O157: STEC o157; HAV: hepatitis-A-virus; hosp: hospitalized; HEV: hepatitis-E-virus.

Notes:

a) per 100,000 inhabitants; b) reported cases; c) : estimated norovirus-associated hospitalized cases derived from RIVM laboratory surveillance data and therefore not directly comparable to numbers from before 2012; d) known for 57 of the 65 cases; e) known for 77 of the 85 cases; f) known for 84 of the 90 cases; g) known for 71 of the 79 cases; h) known for 68 of the 76 cases; i) known for 60 of the 64 cases.

3.2 Disease incidence

Ten of the selected pathogens (i.e. *Campylobacter* spp.; STEC O157; *Salmonella* spp.; all three toxin-producing bacteria; norovirus; rotavirus; *Cryptosporidium* spp.; *Giardia* spp.) cause GE. The other four pathogens (i.e. *Listeria monocytogenes*; *Toxoplasma gondii*; hepatitis-A virus; hepatitis-E virus) cause other diseases (e.g. listeriosis, hepatitis, toxoplasmosis). The incidence of gastroenteritis by pathogen in 2016 is presented in Table 4. The incidence of diseases by non-gastrointestinal pathogens in 2016 is presented in Table 5. The incidence by the 14 pathogens for the years 2012-2016 is presented in Figure 1 and in Table A.4 in Annex II.

There was an overall increase of the estimated total number of foodborne diseases due to the 14 pathogens from 1,682,000 in 2015 to 1,721,000 in 2016. The salmonella outbreak associated with contaminated eggs in 2016 resulted in a slightly higher incidence compared to 2015. But also the incidence of gastroenteritis due to norovirus and cryptosporidiosis, and the incidence of listeriosis increased in 2016 compared to 2015. The incidence of gastroenteritis due to rotavirus and *Campylobacter* decreased. The estimated incidence of the remaining pathogens did not changed, mostly because no trend information based on surveillance data was available.

Table 4. Mean incidence and 95% uncertainty interval (between brackets) of gastroenteritis by pathogen in the Netherlands, 2016

Pathogen	General population (x 1,000)	GP visit (x 1,000)	Hospitalised (x 1,000)	Fatal cases
All causes	4,812 (3986-5720)	222 (71-522)	21 -	NA#
Bacteria – infectious				
Campylobacter spp.	79 (10-219)	19 (9-35)	1.1 (0.4-2.1)	57 (38-79)
STEC O157	2 (0-9)	0 (0-0)	0.02 (0.02-0.02)	4 (2-7)
Salmonella spp.	32 (3-98)	4.9 (3-8)	1.0 (0.4-2)	32 (28-37)
Bacteria – toxin producing				
Bacillus cereus	52 (19-121)	7.3 (2-20)	0.2 (0.1-0.5)	0 -
Clostridium perfringens	171 (60-355)	31 (8-80)	0.3 (0.1-0.6)	5 (0-20)
Staphylococcus aureus	287 (134-517)	40 (11-95)	1.5 (0.6-2.8)	7 (0-28)
Viruses				
Norovirus	765 (527-1096)	18 (10-29)	1.8 (0.9-3.1)	82 (35-155)
Rotavirus	138 (72-240)	8 (5-12)	5.2 (3.7-6.9)	23 (7-51)
Protozoa				
Cryptosporidium spp.	109 (37-270)	7 (3-12)	0.5 (0.2-1.1)	7 (0-30)
Giardia spp.	83 (46-156)	8 (4-13)	0.4 (0-1.4)	2 (0-9)

Table 5. Mean incidence and 95% uncertainty interval (between brackets) of non-gastrointestinal pathogen in the Netherlands, 2016

Pathogen	Incidence *mean (95% CI)*		Fatal cases *mean (95% CI)*	
Listeria monocytogenes				
Perinatal	7	*	4	*
Acquired	89	*	8	*
Hepatitis-A virus	397	(254-637)	1	(1-2)
Hepatitis-E virus	1863	(1099-2830)	21	(7-47)
Toxoplasma gondii				
Congenital	344	(179-603)	12	(7-21)
Acquired#	423	(201-722)	0	

*No uncertainty because *Listeria* cases were acquired through surveillance; # chorioretinitis only

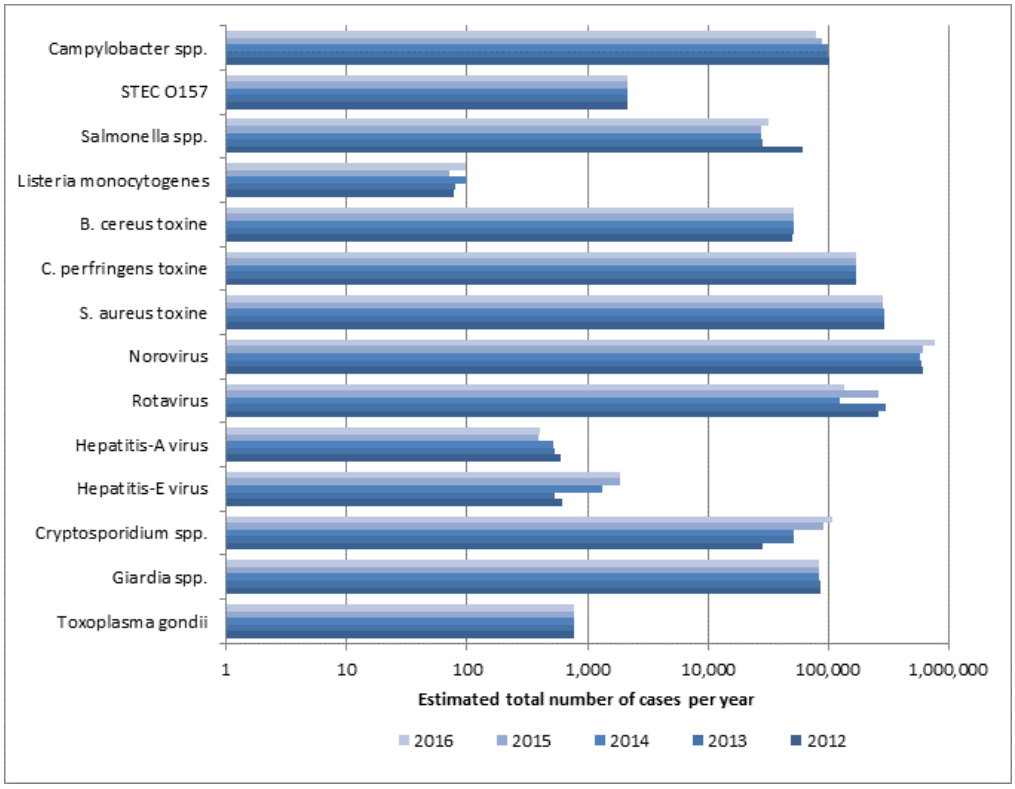

Figure 1. Comparison of mean incidence of food-related pathogens, 2012- 2016

* The estimates that are presented here for 2012-2015 cannot be compared with previous estimates due to: new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp..

The total number of deaths due to foodborne disease decreased from 276 in 2015 to 266 in 2016 (see Table A.5 in Annex II).

3.3 Disease burden by pathogen

Table 6 presents the burden of disease by pathogen for the year 2016 for the total Dutch population, as DALY per 100,000 inhabitants and as DALY per 1,000 cases, both undiscounted and discounted.

The total burden of disease of the 14 pathogens decreased by 170 DALY from 12,190 DALY in 2015 (Table A.6 in Annex II) to 12,020 in 2016, but was higher than in 2014 (11,790 DALYs) - the year with the lowest disease burden in the past five years. Large differences in burden of disease between 2015 and 2016 were found for rotavirus (-600 DALYs), *Campylobacter* (-450 DALYs), norovirus (+450 DALYs), *Listeria* (+200 DALY) and *Salmonella* infections (+200 DALYs). The largest burden at population level was caused by *Campylobacter* spp. (3,570 DALY) and norovirus (2,250 DALYs) followed by *Toxoplama gondii* (1,900 DALYs). Perinatal listeriosis was the disease outcome with the highest individual burden among all pathogens (53 DALY per case), followed by congenital toxoplasmosis (4.7 DALY per case).

Table 6 Mean total DALY per year, DALY per 100,000 inhabitants and DALY per 1000 cases of illness in the Netherlands, 2016

Pathogen	DALY/year		DALY per 100,000/year		DALY per 1,000 cases	
Discount rate	0%	1.5%	0%	1.5%	0%	1.5%
Bacteria – infectious						
Campylobacter spp.	3,573	3,149	21	19	45	40
STEC O157	152	118	1	1	71	55
Salmonella spp.	1,389	1,226	8	7	43	38
L. monocytogenes (perinatal)	370	210	2.2	1.2	52,808	29,958
L. monocytogenes (acquired)	78	74	0.5	0.4	880	835
L. monocytogenes (total)	448	284	3	2	4,665	2,953
Bacteria – toxin producing						
Bacillus cereus	32	32	0	0	1	1
Clostridium perfringens	196	191	1	1	1	1
Staphylococcus aureus	220	211	1	1	1	1
Viruses						
Norovirus	2,248	2,036	13	12	3	3
Rotavirus	673	601	4	4	5	4
Hepatitis-A virus	44	35	0	0	110	88
Hepatitis-E virus	738	588	4	3	396	316
Protozoa						
Cryptosporidium spp.	185	177	1.1	1.0	1.7	1.6
Giardia spp.	221	218	1.3	1.3	2.6	2.6
Toxoplasma gondii (congenital)	1,622	924	9.6	5.4	4,715	2,685
Toxoplasma gondii (acquired)	281	206	1.7	1.2	664	488
Toxoplasma gondii (total)	1,903	1,130	11	6.7	2,481	1,473
TOTAL	12,021	9,997	71	59		

* The ranking of pathogens has changed with previous reports due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.; and b) due to necessary model adaptations (i.e. new disability weights [9] (see Table A.2 in Annex I) and life tables (Table A.1 in Annex I)).

In Figure 2 we show per pathogen the contribution of years lived with disability (YLD) associated with acute infections, YLD associated with sequelae and years of life lost (YLL) due to premature mortality to total DALY. YLD associated with acute infections contributed 13% to the total disease burden; YLD associated with sequelae/residuals contributed 38% and YLL 49% of the total disease burden. The distribution between the different categories varied between pathogens, see Figure 2 for details.

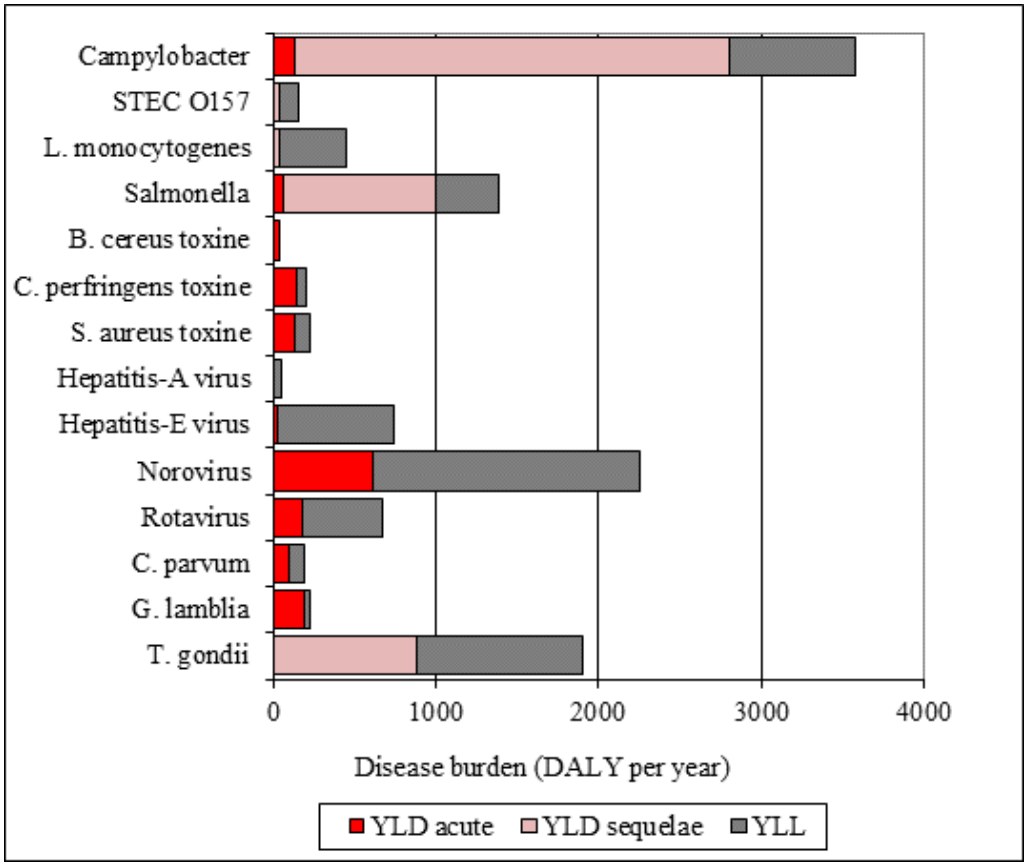

Figure 2. Mean DALY per year of food-related pathogens in 2016, split up into YLD associated with acute infections; YLD associated with sequelae and YLL.

To enable comparison of the burden of disease estimates from 2012 and onwards we re-estimated the disease burden by pathogen and total for the years 2012 to 2016 using the new disability weights and new life tables. The results of this re-estimation are presented in Figure 3 and in Table A.6 in Annex II.

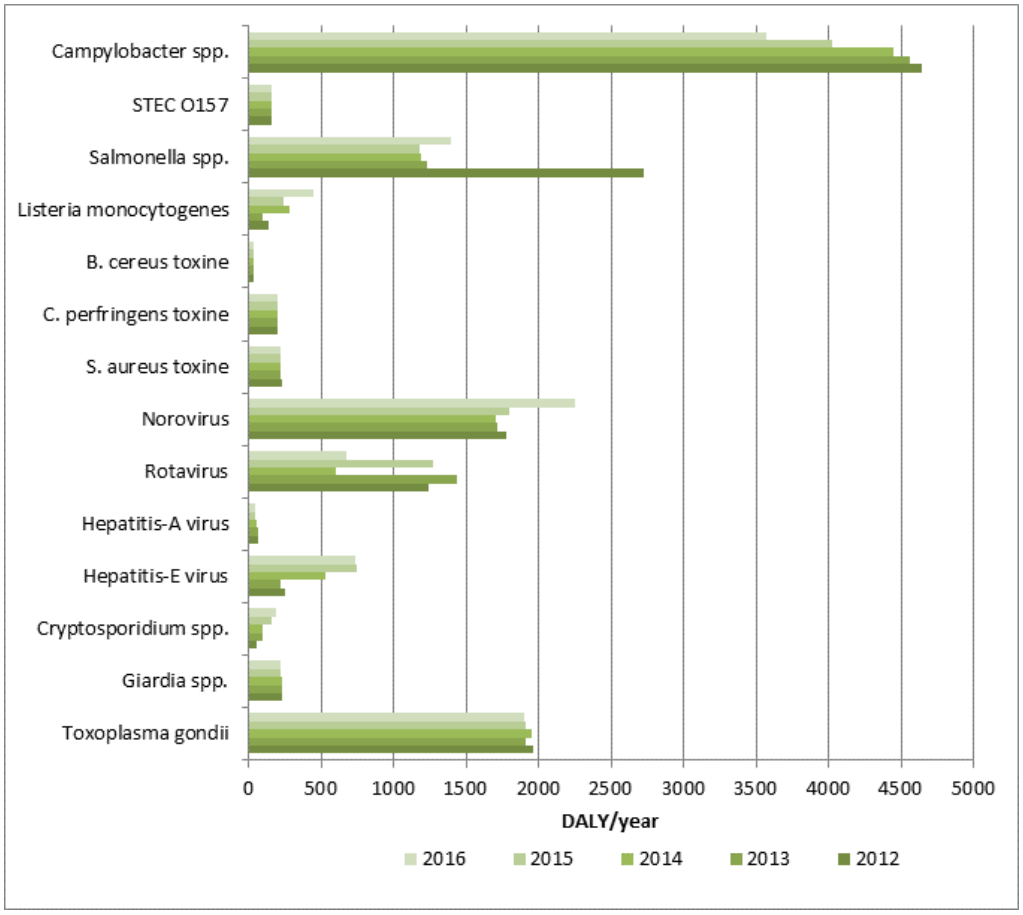

Figure 3. Comparison of disease burden (undiscounted DALYs) of food-related pathogens in 2012-2016

* The estimates that are presented here for 2012-2015 cannot be compared with previous estimates due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.; and b) new disability weights [9] (see Table A.2 in Annex I) and life tables (see Table A.1 in Annex I).

3.4 Cost-of-illness by pathogen

The total COI was 4.5 €M lower in 2016 compared to 2015 (see Table A.7-b in Annex II) and was estimated at 430 M€ (discounted at 4%) in 2016 (Table 7 and Figure 5). The three pathogens causing the largest COI are norovirus (130 M€), *Campylobacter* spp. (63 M€) and GE due to *Staphylococcus aureus* toxin (59 M€). The lowest contribution to the COI was by hepatitis-A virus (0.6 M€). Predominated changes compared to 2015 were for rotavirus (-28 M€), *Campylobacter* (-7 M€), norovirus (+25 M€), *Cryptosporidium* (+3 M€) and *Salmonella* infections (+2 M€). The average cost per case were largest for perinatal *Listeria gondii* infections (0.14 €M/1000 cases).

Table 7 Estimated mean total costs of illness (COI), mean COI per 100,000 inhabitants and mean COI per case of illness in the Netherlands, 2016

Pathogen	COI/year (M€)		COI per 100,000 (k€)		COI per 1,000 cases (k€)	
Discount rate	0%	4%	0%	4%	0%	4%
Bacteria – infectious						
Campylobacter spp.	68	63	401	370	862	795
STEC O157	11	5	63	32	5,013	2,560
Salmonella spp.	23	21	134	125	708	659
L. monocytogenes (perinatal)	2.5	1.0	15	6	364,255	137,311
L. monocytogenes (acquired)	2.4	2.2	14	13	26,775	25,270
L. monocytogenes (total)	4.9	3.2	29	19	51,383	33,439
Bacteria – toxin producing						
Bacillus cereus	11	11	63	63	205	205
Clostridium perfringens	28	28	167	167	166	166
Staphylococcus aureus	59	59	349	349	207	207
Viruses						
Norovirus	130	130	767	767	170	170
Rotavirus	44	44	259	259	320	320
Hepatitis-A virus	0.6	0.6	3.7	3.7	1,568	1,568
Hepatitis-E virus	8	8	49	49	4,500	4,500
Protozoa						
Cryptosporidium spp.	25	25	149	149	232	232
Giardia spp.	16	16	93	93	190	190
Toxoplasma gondii (congenital)	43.1	13.7	254	81	125,202	39,962
Toxoplasma gondii (acquired)	1.1	1.1	7	7	2,694	2,685
Toxoplasma gondii (total)	44	15	260	88	57,645	19,405
TOTAL	**473**	**430**	**2,787**	**2,533**		

Used abbreviations: million € (M€); *1000 € (k€).

In Figure 4 the mean COI per year was split up in healthcare costs, patient/family costs and costs in other sectors. The latest were mostly productivity losses of patients and caregivers being absent from work. Healthcare costs accounted for 21% of the total costs for the 14 pathogens, patient/family costs for 3% and costs in other sectors accounted for 77%. The distribution between the different cost categories varied between pathogens, as can be seen in Figure 4.

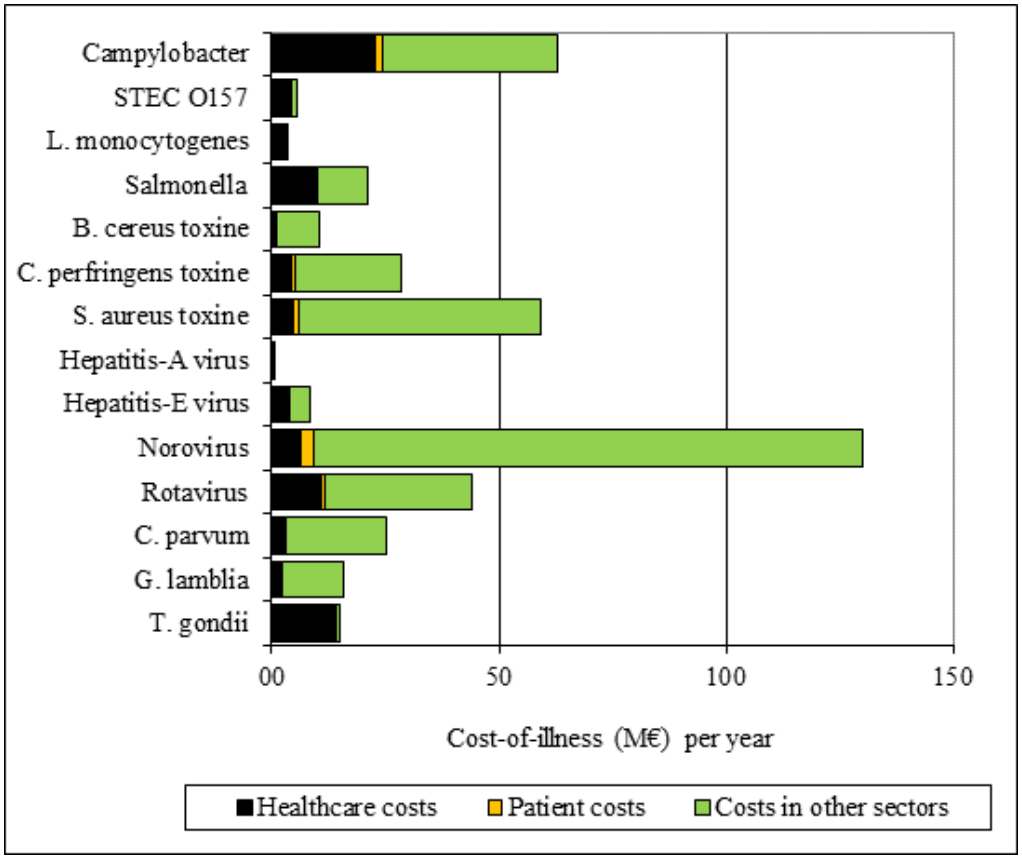

Figure 4. Mean cost-of-illness (discounted) per year of food-related pathogens in 2016, split up into healthcare costs, patient costs and costs in other sectors.

The mean COI estimates - by pathogen and total - for the years 2012 to 2016 were re-estimated because of the use of new references prices and are presented in Figure 5 and in Table A.7 in Annex II.

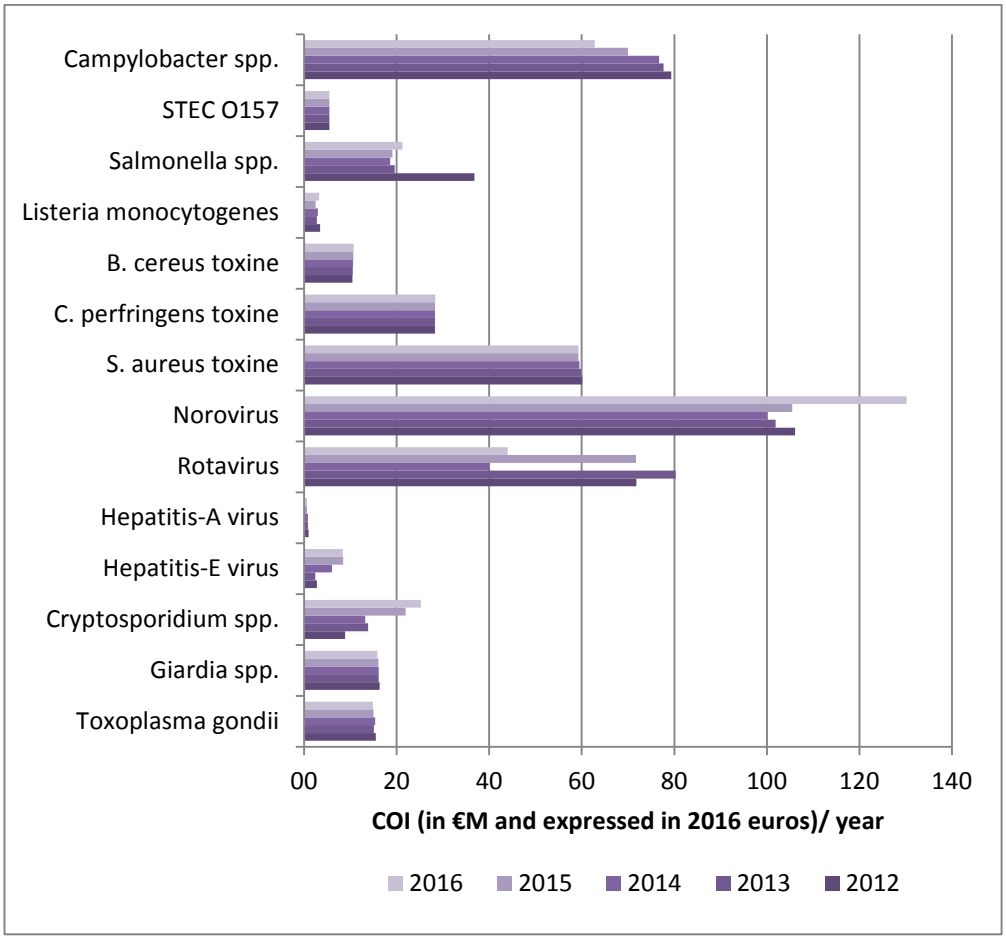

*Figure 5. Comparison of cost-of-illness (M€, discounted at 4% and expressed in 2016 euros) of food-related pathogens in 2012-2016**

* The estimates that are presented here for 2012-2015 cannot be compared with earlier estimates due to: a) new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp.; and b) new reference prices (see Table A.3 in Annex I, and a shorter friction period (i.e. 12 weeks vs 26 weeks).

3.5 Attribution

The attribution results for DALYs and COI of foodborne diseases in 2016 are presented in Table 8 for the main pathways and in Table 9 for the different food groups. More details can be found in the Tables A.8 – A.15 in Annex II. Foodborne disease burden accounted for 39% of the total burden (i.e. 4,710 DALYs per year), and 40% of the total COI (i.e. 171 M€). About 53% of the foodborne burden was associated with meat (i.e. poultry, pork, beef & lamb). 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.

Table 8 Attribution of the mean incidence, fatalities, disease burden and cost-of-illness of foodborne disease[a] to the major transmission pathways in the Netherlands, 2016

Main pathway	Food	Environment	Human	Animal	Travel	Total
Incidence (per year)	672,785	218,294	584,132	95,048	150,385	1,720,644
Deaths (per year)	90	46	71	24	35	266
Disease burden (DALY, undiscounted))	4,708	2,399	2,250	1,183	1,480	12,021
Disease burden (DALY, discounted (1.5%))	3,803	1,910	2,014	1,022	1,248	9,997
Cost of illness (M€, undiscounted)[b]	194	77	122	34	46	473
Cost of illness (M€, discounted (4%)) [b]	171	64	120	31	43	430

a) Due to the 14 pathogens included in this study

b) Costs are expressed in 2016 euros and in million € (M€).

Table 9 Attribution of the mean incidence, fatalities, disease burden and cost-of-illness of foodlborne disease[a] to food group in the Netherlands, 2016

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish& shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Incidence (per year)	109,521	45,073	56,156	21,974	54,903	56,069	39,395	15,785	40,175	120,883	112,851	672,785
Deaths (per year)	9.5	11.6	18	5.6	7.3	7.9	6.1	2.1	3.4	5.5	13	90
Disease burden (DALY, undiscounted))	586	874	1,035	248	364	345	304	88	137	249	479	4,708
Disease burden (DALY, discounted (1.5%))	446	606	895	217	291	283	247	77	119	216	407	3,803
Cost of illness (M€, undiscounted)[b]	29	25	26	7	16	14	12	4	9	26	26	194
Cost of illness (M€, discounted (4%)) [b]	24	16	23	7	14	13	10	4	9	26	24	171

a) Due to the 14 pathogens included in this study

b) Costs are expressed in 2016 euros and in million € (M€).

The foodborne disease burden increased by 66 DALYs from 4,642 DALYs in 2015 to 4,708 DALYs in 2016, whereas the COI slightly decreased by 0.5 M€ from 171.8 M€ in 2015 to 171.3 M€ in 2016, see Tables 10 and 11 for food-related DALY and COI estimates for the years 2012-2016.

Table 10 Disease burden (DALY per year, undiscounted) attributed to food in the Netherlands from 2012 to 2016, total and by pathogen

Pathogen	**Disease burden (DALY) per year***				
	2012	**2013**	**2014**	**2015**	**2016**
Campylobacter spp.	1951	1917	1869	1691	1501
STEC O157	61	61	61	61	61
Salmonella spp.	1486	670	649	643	757
Listeria monocytogenes	94	68	191	165	310
B. cereus toxin	28	28	28	28	28
C. perfringens toxin	176	176	177	177	177
S. aureus toxin	194	194	193	192	192
Norovirus	297	286	285	301	375
Rotavirus	161	186	78	165	88
Hepatitis-A virus	7	7	6	5	5
Hepatitis-E virus	34	30	73	103	102
Cryptosporidium spp.	6	11	11	19	22
Giardia spp.	29	29	29	29	29
Toxoplasma gondii	1093	1068	1088	1063	1062
Total	**5618**	**4732**	**4738**	**4642**	**4708**

* The estimates that are presented here for 2012-2015 cannot be compared with previous estimates due to: a) new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp.; and b) new disability weights [9] (see Table A.2 in Annex I) and life tables (see Table A.1 in Annex I).

Table 11– Attribution of mean COI (M€/year discounted at 4% and expressed in 2016 euros) to food in the Netherlands for 2012-2016, total and by pathogen

Pathogen	**COI per year (million €/year)***				
	2012	**2013**	**2014**	**2015**	**2016**
Campylobacter spp.	33.3	32.6	32.2	29.4	26.4
STEC O157	2.2	2.2	2.2	2.2	2.2
Salmonella spp.	20.1	10.6	10.1	10.4	11.6
Listeria monocytogenes	2.4	1.9	2.0	1.7	2.2
B. cereus toxin	9.3	9.4	9.4	9.5	9.5
C. perfringens toxin	25.5	25.5	25.5	25.6	25.6
S. aureus toxin	52.4	52.2	51.9	51.7	51.7
Norovirus	17.7	17.0	16.7	17.6	21.7
Rotavirus	9.3	10.4	5.2	9.3	5.7
Hepatitis-A virus	0.1	0.1	0.1	0.1	0.1
Hepatitis-E virus[a]	0.4	0.3	0.8	1.2	1.2
Cryptosporidium spp. [a]	1.1	1.6	1.6	2.6	3.0
Giardia spp. [a]	2.1	2.1	2.1	2.1	2.1
Toxoplasma gondii	8.6	8.4	8.6	8.4	8.3
Total	**184.6**	**174.5**	**168.5**	**171.8**	**171.3**

* The estimates that are presented here for 2012-2015 cannot be compared with earlier estimates due to: a) new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp.; and b) new reference prices (see Table A.3 in Annex I) and a shorter friction period (i.e. 12 weeks vs 26 weeks).

3.6 Model update effect

3.6.1 Updated incidences

Using available RIVM laboratory surveillance for hepatitis-E virus and *Cryptosporidum* spp., and assuming no negative trend correction for *Giardia spp*. but a stable incidence since 2007 (i.e. the last year of RIVM laboratory surveillance data for *Giardia* spp.) resulted in far higher incidence estimates than presented in earlier reports (see Table 12), and hence higher disease burden and higher COI estimates for these years.

Table 12– Updated incidences and old estimates for 2012-2015

Incidences in population		**2012**	**2013**	**2014**	**2015**
Hepatitis-E virus	Old	53	53	53	53
	New	617	540	1,335	1,878
Cryptosporidum spp	Old	27,941	27,689	27,583	27,806
	New	28,125	52,137	51,752	91,898
Giardia spp.	Old	57,163	48,695	48,524	40,608
	New	85,766	85,217	84,495	83,784

3.6.2 New disability weights and new life tables

The application of the new disability weights - all derived from a single study among citizens of four European countries, including the Netherlands - resulted in lower disability weights for mostly all acute infections with as consequences lower YLD estimates than compared to disability weights derived with older methodology (see Table 13). For some of the chronic sequelae, in particular all the sequelae related to congenital *Toxoplasma* infections disability weights were also lower, resulting in lower YLD estimates (Table 13). Only mild gastro-enteritis (GE) cases not requiring medical help with a disability weight of 0 in the old methodology, were valued higher with the new methodology, what in particular for norovirus resulted in higher YLD (Table 13).

The new life tables have impacted mostly the YLL estimates, resulting in either slightly higher estimates, or no difference.

In short, the application of the new disability weights resulted in lower non-fatal burden of disease for some of the pathogens (i.e. all three toxin-producing bacteria; rotavirus, hepatitis-E and hepatitis-A virus; *Cryptosporidium* spp., *Toxoplasma gondii*), and in higher estimates for other pathogens (i.e. *Campylobacter* spp., STEC O157, *Salmonella* spp., *Listeria monocytogenes* and norovirus). The new ranking of pathogens is therefore slightly different compared to rankings of previous iterations. In 2016, *Campylobacter* infections had the highest disease burden, followed by norovirus and *Toxoplasma gondii*. In previous years *Toxoplasma gondii* ranked second, except for the year 2012 (a large salmonella outbreak).

*Table 13. Estimated mean YLD, YLL and total DALY per year using old disability weights with corresponding durations, and old life tables (i.e. old methodology) and estimated mean YLD, YLL and total DALY per year using new disability weights with corresponding durations and new life tables (i.e. new methodology) by pathogen in the Netherlands, 2016**

Pathogen	**DALY/year**					
	Old methodology			**New methodology**		
	YLD	YLL	DALY	YLD	YLL	DALY
Bacteria – infectious						
Campylobacter spp.	2,361	627	2,989	2,806	766	3,573
STEC O157	23	115	138	37	115	152
Salmonella spp.	748	311	1,059	998	392	1,389
L. monocytogenes	47	379	425	41	407	448
Bacteria – toxin producing						
Bacillus cereus	118	0	118	32	0	32
Clostridium perfringens	484	60	544	136	60	196
Staphylococcus aureus	661	94	755	126	94	220
Viruses						
Norovirus	338	1,634	1,972	616	1,634	2,248
Rotavirus	335	502	837	171	502	673
Hepatitis-A virus	24	42	66	2	42	44
Hepatitis-E virus	137	716	853	21	716	738
Protozoa						
Cryptosporidium spp.	123	88	211	97	88	185
Giardia spp.	131	30	161	190	30	221
Toxoplasma gondii	2,453	981	3,434	875	1,027	1,903

** For details on life tables – old and updated values - see Table A.1 in Annex I and for disability weights and durations – old and updated values - see Table A.2 in Annex I.*

3.6.3 New reference prices

The application of more recent reference prices and a shorter friction period (12 weeks vs 26 weeks) had only a marginal impact on the results (see Table 14), and had no impact at all on the ranking of the pathogens itself.

Table 14. Estimated mean health care costs, costs in other sectors and total costs per year using old reference prices and a 26-week friction period (i.e. old methodology) and new reference prices and a 12-week friction period (i.e. new methodology) by pathogens in the Netherlands, 2016

Pathogen	**Cost-of-illness per year** *(Million €, discounted at 4% and expressed in 2016 euros)*					
	Old methodology			**New methodology**		
	Health care cost	Costs in other sectors	Total costs*	Health care cost	Costs in other sectors	Total costs*
Bacteria – infectious						
Campylobacter spp.	23.3	37.7	62.8	22.8	38.5	62.8
STEC O157	4.5	1.0	5.5	4.5	1.0	5.5
Salmonella spp.	9.6	11.1	21.2	9.6	11.1	21.2
L. monocytogenes	3.0	0.2	3.2	3.0	0.2	3.2
Bacteria – toxin producing						
Bacillus cereus	1.0	9.5	10.7	1.0	9.5	10.7
Clostridium perfringens	4.3	23.3	28.3	4.3	23.3	28.3
Staphylococcus aureus	4.9	53.1	59.3	4.9	53.1	59.3
Viruses						
Norovirus	6.4	121.0	130.2	6.4	121.0	130.2
Rotavirus	10.9	32.4	44.0	10.9	32.4	44.0
Hepatitis-A virus	0.2	0.4	0.6	0.2	0.4	0.6
Hepatitis-E virus	3.9	4.4	8.4	3.9	4.4	8.4
Protozoa						
Cryptosporidium spp.	2.8	22.0	25.2	2.8	22.0	25.2
Giardia spp.	2.0	13.4	15.8	2.0	13.4	15.8
Toxoplasma gondii	13.9	0.9	14.9	13.9	0.9	14.9
TOTAL	90.3	331.4	430.1	90.3	331.4	430.1

** Note the total costs included healthcare costs, costs for the patient and / or his family (~3% of total costs and not shown) and costs in other sectors (e.g. productivity losses).*

4 Discussion

Although we observed an increasing trend in incidence, disease burden and cost-of-illness for norovirus, hepatitis-E virus and *Cryptosporidium* spp., the overall estimated disease burden of 14 enteric pathogens in 2016 is slightly lower than in 2015 (12,020 versus 12,190 DALYs), confirming a continuing decrease since 2012. The share of foodborne transmission is about 40%, and was slightly higher in 2016 than in 2015 (4,708 versus 4,642 DALYs), but lower than the years 2012-2014. Both the overall COI and the foodborne-related COI show a decreasing trend over the years, and were lowest since 2012. However, to what extent/in how far/whether this trend will continue is speculative as the increase of norovirus-associated COI was in 2016 partly compensated by a sharp decrease in rotavirus-associated costs-of-illnesses. Whether the two-year cycle observed in recent years for rotavirus will also apply to 2017 - low rotavirus incidence in 2016, thus high rotavirus incidence in 2017 –and there is no drastic reduction of norovirus incidences (and it seems like there is an increase for rotavirus, but no decrease in norovirus) than we might expect an increase in both costs and DALYs in 2017. These data will be shown in the next update of the burden estimates.

In the past years several surveillance and registrations systems have been started, have been changed or were available but were so far not used in previous reports [1-6]. We made use of these data for hepatitis-E virus, *Cryptosporidium* spp., and norovirus, and re-estimated disease burden and COI from previous years (i.e. 2012-2015) using these new data. This is why burden of disease and COI estimates for these three pathogens presented in previous reports [1-6] cannot be compared to the results presented in the current report

In the current report, we used new disability weights and a more recent life table. Both changes had an impact on the estimated disease burden. This is why burden of disease estimates presented in previous reports [1-6] cannot be compared to the results presented in the current report. We therefore have re-estimated the disease burden from 2012 onwards. The currently used disability weights are, opposite to the older ones, derived from a single study among 30,660 citizens of four European countries including the Netherlands. The older ones were derived from different studies using partly varying methodologies and were derived in different populations. The new disability weights are well applicable to the Netherlands and are an important improvement to the comparability across diseases (e.g. for example all diseases presented in the 2017 "State of Infectious Diseases in the Netherlands, 2016" [29]). Furthermore, ECDC use the same disability weights in their burden of disease toolkit, a toolkit freely available and accessible to everybody, including all member states of the European Union [16]. The application of the new disability weights resulted in lower YLDs for almost all health states associated with acute infections, except for mild gastro-enteritis which was previously weighted with zero. But also for some of the chronic sequelae, in particular all the sequelae related to congenital *Toxoplasma* infections, had lower disability weights. The new life tables that were used in this study resulted mostly in higher YLL estimates

compared to the YLL estimates with old life tables. The application of the new disability weights resulted in lower disease burden for some of the pathogens (i.e. all three toxin-producing bacteria; rotavirus, hepatitis-E and hepatitis-A virus; *Cryptosporidium* spp., *Toxoplasma gondii*), whereas for other pathogens higher disease burden estimates were obtained (i.e. *Campylobacter* spp., STEC O157, *Salmonella* spp., *Listeria monocytogenes* and norovirus). These changes had an impact on the ranking with *Campylobacter* infections presenting the highest disease burden, and *Toxoplasma gondii* mostly only second place. In previous iterations this used to be the other way around.

A last methodological change was the use of new references prices and a shorter friction period representing the current labour market [12, 13]. These adaptations had only a marginal impact on the calculated cost-of-illness estimates. However, for comparison reason we also re-estimated all COI estimates for the years 2012-2016 and presented them in the current report.

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6 Annex I: Adapted model parameters

Table A.1 - Standard loss functions used – old and updated life expectancies[a]

Age-group (years)	GBD 1990 (i.e. old life expectancies)		GBD 2010 (i.e. new life expectancies)
	Males	Females	Persons
0	79.94	82.43	85.68
1-4	77.77	80.28	83.63
5-9	72.89	75.47	78.76
10-14	67.91	70.51	73.79
15-19	62.93	65.55	68.83
20-24	57.95	60.63	63.88
25-29	52.99	55.72	58.94
30-34	48.04	50.83	54.00
35-39	43.1	45.96	49.09
40-44	38.2	41.13	44.23
45-49	33.38	36.36	39.43
50-54	28.66	31.68	34.72
55-59	24.07	27.1	30.10
60-64	19.65	22.64	25.55
65-69	15.54	18.32	21.12
70-74	11.87	14.24	16.78
75-79	8.81	10.59	12.85
80-84	6.34	7.56	9.34
85+	3.82	3.59	5.05

a) Source: [11]:

Table A.2 – Disability weights and durations – old and updated values

Pathogen	Health state	Old parameters		Updated parameters			
		Disability weight	Duration (in years)	Disability weight[b]	Description of used disability weight	Duration (in years)	Source (duration)
Campylobacter spp.							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[17, 18]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.03	[17, 18]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.04	[17, 18]
	GBS - Clinical phase, mild	0.09	1	0.012	Derived from motor impairment, mild & moderate[d]	1.00	[7]
	GBS - Clinical phase, severe	0.28	1	0.229	Derived from intensive care unit admission; motor impairment, moderate & severe [e]	1.00	[7]
	GBS - Residual symptoms	0.16	41	0.110	Derived from motor impairment, mild, moderate & severe [f]	41.00	[7]
	ReA - mild (i.e. not visiting a GP)	0.023	1	0.034	Derived from musculoskeletal problems, upper limbs, mild & musculoskeletal problems, lower limbs, mild [g]	0.61	[17, 18]
	ReA - moderate (i.e. visiting a GP)	0.115	1	0.116	Derived from musculoskeletal problems, upper limbs, moderate & musculoskeletal problems, lower limbs, moderate [g]	0.61	[17, 18]
	ReA -severe (i.e. hospitalized)	0.186	1	0.344	Musculoskeletal problems, generalized, moderate [h]	0.61	[17, 18]
	Irritable bowel syndrome	0.042	5	0.062	IBS	5.00	[7]
	Inflammatory bowel	0.13	Rem. LE	0.221	Crohn's disease or ulcerative colitis	Rem. LE	[7]

Pathogen	Health state	Old parameters		Updated parameters			
		Disability weight	Duration (in years)	Disability weight[b]	Description of used disability weight	Duration (in years)	Source (duration)
	disease						
STEC O157							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[19]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.02	[19]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.02	[19]
	EDRD	0.154	49	0.279	Derived from generic uncomplicated disease: worry and daily medication and ESRD, on dialyse	49.00	[7]
	HUS	0.123	1	0.258	Derived from intensive care unit admission & infectious disease, acute episode, severe [j]	0.06	[19]
Salmonella spp.							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.02	[18]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.03	[18]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.04	[18]
	ReA - mild (i.e. not visiting a GP)	0.023	1	0.034	Derived from musculoskeletal problems, upper limbs, mild & musculoskeletal problems, lower limbs, mild [g]	0.61	[17, 18]
	ReA - moderate (i.e. visiting a GP)	0.115	1	0.116	Derived from musculoskeletal problems, upper limbs, moderate &	0.61	[17, 18]

Pathogen	Health state	Old parameters		Updated parameters			
		Disability weight	Duration (in years)	Disability weight[b]	Description of used disability weight	Duration (in years)	Source (duration)
					musculoskeletal problems, lower limbs, moderate [g]		
	ReA -severe (i.e. hospitalized)	0.186	1	0.344	Musculoskeletal problems, generalized, moderate [h]	0.61	[17, 18]
	Irritable bowel syndrome	0.042	5	0.062	IBS	5.00	[7]
	Inflammatory bowel disease	0.13	Rem. LE	0.221	Crohn's disease or ulcerative colitis	Rem. LE	[7]
Norovirus							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[18]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.02	[18]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.02	[18]
Rotavirus							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[18]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.02	[18]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.02	[18]
Cryptosporidium spp.							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[20]

Pathogen	Health state	Old parameters		Updated parameters			
		Disability weight	Duration (in years)	Disability weight[b]	Description of used disability weight	Duration (in years)	Source (duration)
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.02	[20]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.05	[20]
Giardia spp.							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.03	[20]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.03	[20]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.08	[20]
B. cereus toxin							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[21]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.01	[21]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.04	[21]
C. perfringens toxin							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[21]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.01	[21]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.04	[21]

Pathogen	Health state	Old parameters		Updated parameters			
		Disability weight	Duration (in years)	Disability weight[b]	Description of used disability weight	Duration (in years)	Source (duration)
S. aureus toxin							
	GE - mild (i.e. not visiting a GP)	0	-	0.073	Diarrhea, mild	0.01	[21]
	GE - moderate (i.e. visiting a GP)	0.015	1	0.149	Diarrhea, moderate	0.01	[21]
	GE - severe (i.e. hospitalized)	0.041	1	0.239	Diarrhea, severe	0.03	[21]
Listeria moncytogenes							
	Acquired infection						
	Acquired listeriosis	0.041	1	0.231	Derived from Intensive care unit admission & infectious diseases, acute episode, severe [k]	0.06	[22]
	Permanent disability due to meningitis	0.25	13	0.266	From lowest to highest motor and cognitive difficulties[c]	13.00	[7]
	Perinatal infection						
	Symptomatic infection/meningitis	0.31	1	0.302	Derived from Intensive care unit admission & infectious diseases, acute episode, severe [k]	0.04	[23]
	Permanent disability due to meningitis	0.25	Rem. LE	0.266	From lowest to highest motor and cognitive difficulties[c]	13.00	[7]
Hepatitis-A virus							
	Hepatitis - mild (i.e. not visiting a GP)	0.011	1	0.007	Infectious disease, acute epsiode, mild	0.04	[21]
	Hepatitis - moderate (i.e. visiting a GP)	0.058	1	0.051	Infectious disease, acute epsiode, moderate	0.08	[21]
	Hepatitis - severe (i.e. hospitalized)	0.353	0.3	0.125	Infectious disease, acute epsiode, severe	0.08	[21]

Pathogen	Health state	Old parameters		Updated parameters			
		Disability weight	Duration (in years)	Disability weight[b]	Description of used disability weight	Duration (in years)	Source (duration)
Hepatitis-E virus							
	Hepatitis - mild (i.e. not visiting a GP)	0.011	1	0.007	Infectious disease, acute epsiode, mild	0.08	[21]
	Hepatitis - moderate (i.e. visiting a GP)	0.058	1	0.051	Infectious disease, acute epsiode, moderate	0.08	[21]
	Hepatitis - severe (i.e. hospitalized)	0.353	0.3	0.125	Infectious disease, acute epsiode, severe	0.16	[21]
Toxoplasma gondii							
	Acquired infection						
	Chorioretinitis	0.08	Rem. LE	0.015	Conjunctivitis without corneal scar[c]	Rem. LE	[7]
	Congenital infection						
	Chorioretinitis	0.08	Rem. LE	0.015	Conjunctivitis without corneal scar[c]	Rem. LE	[7]
	Post-1 year chorioretinitis	0.08	Rem. LE	0.015	Conjunctivitis without corneal scar[c]	Rem. LE	[7]
	Intracranial calcification	0.01	Rem. LE	0.088	Derived from intellectual disability, mild & moderate[c]	Rem. LE	[7]
	hydrocephalus	0.36	Rem. LE	0.232	Derived from motor plus cognitive impairments, from mild to severe[c]	Rem. LE	[7]
	CNS abnormalities	0.36	Rem. LE	0.097	Derived from intellectual disability, mild & severe [m]	Rem. LE	[7]

Used abbreviations: GBS (Guillain-Barré Syndrom); ReA (Reactive arthritis); LE (life expectancy); Rem. LE (remaining life expectancy); CNS (central nervous system); GE (gastroenteritis).

a) For details see Havelaar et al. [7].
b) Source: Haagsma et al. [9].
c) Same description as described in Colzani et al. [16] to be used in the BCoDE model.
d) Assuming that in the first 3 months 50% have an F-score of 1 (motor impairment, mild) and 50% F-score of 2 (motor impairment, moderate). After 3 months 50% have an F-score of 0 (=recovered) and the remaining cases have an F-score of 1 [17, 24].
e) Assuming that 25% require ventilation (= intensive care unit admission) during 0.25 years and severe motor impairment for the remaining days during the clinical phase. Further assuming that 75% have severe motor impairment for 0.25 years and moderate motor impairment for the remaining days during the clinical phase [17, 25].

f) 15% to 20% of all GBS cases are left with severe neurological deficit, assuming 100% motor impairment, severe. And assuming for the remaining cases that 50% have an F1-score (motor impairment, mild) and 50% have an F2-score (Motor impairment, moderate). [17].
g) Assuming 50% and 50%.
h) Same as Colzani et al. [16], but only for the severe ReA cases.
i) Average length on dialyze before transplantation is age-depending and is, acording to Havelaar et al.[19], for 0-15 years; 16-44 years; 45-64 years and 65 years and older ESRD patients on average 2.1 years; 3.4 years; 9.9 years and remaining LE, respectively; graft survival is according to the same authors 19.8 years. But taking into account that some ESRD patients die during dialyze and/or due to transplantation, we assume for simplification that it is 50% ESRD on dialyse and 50% Generic uncomplicated disease: worry and daily medication
j) According to McPherson et al. [26] were all HUS cases admitted at ICU. Jenssen et al. [27] finds severe complications most of them probably requiring intensive care as well. No information on length of ICU is scarce. Hospital duration is according to Ruzante et al. [22], 13.3 days on average; Jenssen et al. [27] reported that HUS patients were sick for 5 to 6 days before hospital admission. For simplification, we therefore assume 25% ICU and 75% infectious disease, acute episode, severe.
k) According to Ruzante et al.[22] average duration in hospital is 23 days, and according to Haagsma et al. [21], patients stay on average 5 days at ICU; therefore assuming 1/5 ICU and 4/5 infectious diseases, acute episode, severe.
l) According to Bos et al. [23] average duration in hospital is 15 days, and according to Haagsma et al. [21], patients stay on average 5 days at ICU; therefore assuming 1/3 ICU and 2/3 infectious diseases, acute episode, severe
m) Average between mild and severe; Same description as Colzani et al. [16] but with severe as the worst health state rather than moderate as chosen by Colzani et al.[16]. This is more in line with Torgerson et al.[28] and Havelaar et al.[7], who considered CNS abnormalities to be more severe than intracranial calcification.

Table A.3 – Unit cost prices (in 2016 euros) – old and updated values

	Unit costs (in 2016 euros)		
	Old unit cost[a]	New unit cost	Source
Healthcare costs			
Delivery fee for pharmacy (per medication)	6.12	6.08	[13]
Additional fee for first time delivery	3.34	6.08	[13]
GP visit/consultation	31.18	33.43	[13]
GP house visit/per consultation	47.88	50.65	[13]
GP phone call/consultation	15.59	17.22	[13]
Outpatient clinic visit (weighted mean)/consultation	80.17	81.04	[13]
Emergency department visit/consultation	168.12	262.36	[13]
Hospital admission adults in general ward(weighted mean)/day	508.83	482.18	[13]
Hospital admission child in general ward (weighted mean)/day	661.48	635.14	[13]
Intensive care unit/day	2430.57	2041.16	[13]
Revalidation – inpatient/day	378.56	465.97	[13]
Revalidation/hour	122.48	154.99	[13]
Physiotherapy/visit (~0.5 hours)	40.08	33.43	[13]
Mentally/physically disabled institutional care/day	268.99	211.71	[13]
Elderly nursing home/day	268.99	170.18	[13]
Transport by ambulance to hospital (urgent)/trip	561.16	620.96	[13]
Transport by ambulance to revalidation center or nursing home/trip	270.56	275.53	[13]
Patient/family costs			
Car/public transport (per km)	0.22	0.19	[13]
Parking fees (per visit)	3.34	3.04	[13]
Costs in other sectors			
Additional costs for special education			
primary school & kindergarten (student/year)	18,692	18,692	[b]
secondary school (student/year)	23,804	23,804	[b]
PL due to work absence from ***unpaid*** work (per hour)	13.92	14.18	[13]
PL due to work absence from ***paid*** work (per hour)			
for average working person	33.42	35.20	[13]
for working person between 15-19 years	10.32	9.50	[13][c]
for working person between 20-24 years	19.50	18.46	[13][c]
for working person between 25-29 years	26.64	26.19	[13][c]
for working person between 30-34 years	32.07	32.30	[13][c]
for working person between 35-39 years	35.91	37.19	[13][c]
for working person between 40-44 years	37.77	40.30	[13][c]
for working person between 45-49 years	38.82	41.47	[13][c]
for working person between 50-54 years	39.65	41.88	[13][c]
for working person between 55-59 years	40.49	42.10	[13][c]
for working person between 60-64 years	40.54	41.56	[13][c]
for average working parenting caregiver	29.22	32.34	[13][d]
PL due for a fatal case (per death person)			
between 15-19 years)	1,301	542	[13][e]

between 20-24 years	6,941	3,071	[13][e]
between 25-29 years	14,374	7,022	[13][e]
between 30-34 years	18,283	9,247	[13][e]
between 35-39 years	19,675	10,458	[13][e]
between 40-44 years	20,430	10,986	[13][e]
between 45-49 years	21,179	11,375	[13][e]
between 50-54 years	20,045	11,026	[13][e]
between 55-59 years	17,937	9,752	[13][e]
between 60-64 years	9,086	6,164	[13][e]

Used abbreviations: General practitioner (GP); productivity losses (PL)

a) For the details see Mangen et al.[8] Appendix B. Note unit costs were updated to 2016 euros using Dutch consumer price indices (http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71905ned&D1=a&D2=0,95-115&HDR=T&STB=G1&VW=T)

b) Same as in Mangen et al.[8], but updated to 2016 euros.

c) Derived based on the average person productivity losses as given by ZIN [13] and age-specific hour earnings as published by Statistic Netherlands (Available at: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81431NED&D1=2&D2=0-15&D3=0&D4=6-7&HDR=G3,G1,T&STB=G2&VW=T).

d) Based on PL estimates presented in the table, on data from Statistics Netherlands for 2014 (Available at: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71958ned&D1=0-1,4&D2=a&D3=0,29-30&D4=55,60,65,70,l&HDR=T&STB=G1,G2,G3&VW=T; accessed on: 27-09-2016) and assuming, similar as Mangen et al.[8], that apart from single father households (3.2% in 2014) in all other households the mother is the primary caregiver.

e) Productivity losses for fatal cases were estimated assuming a friction period of 12 weeks [13]. Furthermore productivity losses were based on average working hours as reported by Statistics Netherlands (Available online at: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71958ned&D1=0-1,4&D2=a&D3=0,2-11&D4=l&HDR=T&STB=G1,G2,G3&VW=T; accessed on: 26-09-2016) in the corresponding age-groups; but corrected by 18% for bank holidays, vacation, schooling etc. [13] and corrected for the proportion of the population not working in that age-group as reported by Statistics Netherlands (Available online at: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71958ned&D1=0-1,4&D2=a&D3=0,2-11&D4=l&HDR=T&STB=G1,G2,G3&VW=T; accessed on: 26-09-2016).

7 Annex II: Detailed results

Table A.4 – Mean incidences by pathogen in the Netherlands, 2012-2016

Pathogen	**Incidences/year**				
	2012	**2013**	**2014**	**2015**	**2016**
Campylobacter spp.	101,719	99,575	98,156	88,582	78,968
STEC O157	2,137	2,137	2,137	2,137	2,137
Salmonella spp.	61,358	28,083	27,509	27,371	32,212
Listeria monocytogenes	77	79	96	72	96
B. cereus toxine	50,829	51,277	51,530	51,867	52,119
C. perfringens toxine	169,822	169,795	169,880	170,152	170,625
S. aureus toxine	291,399	290,021	288,473	287,504	286,970
Norovirus	617,374	591,505	584,689	614,517	764,658
Rotavirus	258,234	297,078	124,186	260,719	137,618
Hepatitis-A virus	593	534	514	392	397
Hepatitis-E virus[a]	617	540	1,335	1,878	1,863
Cryptosporidium spp. [a]	28,125	52,137	51,752	91,898	108,888
Giardia spp. [a]	85,766	85,217	84,495	83,784	83,328
Toxoplasma gondii	780	769	776	767	767
Total	**1,668,830**	**1,668,748**	**1,485,528**	**1,681,641**	**1,720,646**

a) The estimates that are presented here for 2012-2015 cannot be compared with earlier estimates due to: new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp.

Table A.5 – Mean number of fatal cases by pathogen in the Netherlands, 2012-2016

Pathogen	**Fatal cases/year**				
	2012	**2013**	**2014**	**2015**	**2016**
Campylobacter spp.	78	77	72	65	57
STEC O157	4	4	4	4	4
Salmonella spp.	67	30	28	28	32
Listeria monocytogenes	8	7	11	16	12
B. cereus toxine	0	0	0	0	0
C. perfringens toxine	5	5	5	5	5
S. aureus toxine	7	7	7	7	7
Norovirus	60	59	60	65	82
Rotavirus	40	47	20	43	23
Hepatitis-A virus	2	2	2	1	1
Hepatitis-E virus[a]	7	6	15	22	21
Cryptosporidium spp. [a]	2	3	3	6	7
Giardia spp. [a]	2	2	2	2	2
Toxoplasma gondii	13	12	12	12	12
Total	**294**	**262**	**241**	**276**	**266**

a) The estimates that are presented here for 2012-2015 cannot be compared with earlier estimates due to: new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp.

Table A.6 – Mean disease burden (undiscounted DALY/year) in the Netherlands for the years 2012 until 2016, total and by pathogen

Pathogen	**DALY/year[a]**				
	2012	**2013**	**2014**	**2015**	**2016**
Campylobacter spp.	4646	4565	4450	4025	3573
STEC O157	152	152	152	152	152
Salmonella spp.	2726	1230	1190	1181	1389
Listeria monocytogenes	135	98	277	239	448
B. cereus toxine	31	31	31	32	32
C. perfringens toxine	195	195	195	196	196
S. aureus toxine	223	222	221	220	220
Norovirus	1778	1714	1704	1800	2248
Rotavirus	1237	1432	602	1270	673
Hepatitis-A virus	65	59	57	43	44
Hepatitis-E virus	244	214	529	744	738
Cryptosporidium spp.	53	92	91	158	185
Giardia spp.	227	225	224	222	221
Toxoplasma gondii	1960	1914	1950	1906	1903
Total	**13,672**	**12,143**	**11,673**	**12,188**	**12,021**

a) The estimates that are presented here for 2012-2015 cannot be compared with earlier estimates due to: a) new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp.; and b) the use of new disability weights [9] (see Table A.2 in Annex I) and new life tables (see Table A.1 in Annex I).

Table A.7– Mean discounted COI (4%) in million euros in the Netherlands for 2012-2016, total and by pathogen

Pathogen	**COI per year [a] (Million €, expressed in 2016 euros)**				
	2012	**2013**	**2014**	**2015**	**2016**
Campylobacter spp.	79.3	77.7	76.7	70.0	62.8
STEC O157	5.5	5.5	5.5	5.5	5.5
Salmonella spp.	36.8	19.5	18.6	19.1	21.2
Listeria monocytogenes	3.5	2.8	2.9	2.5	3.2
B. cereus toxine	10.4	10.5	10.6	10.6	10.7
C. perfringens toxine	28.3	28.3	28.3	28.3	28.3
S. aureus toxine	60.1	59.8	59.5	59.3	59.3
Norovirus	106.1	101.9	100.0	105.5	130.2
Rotavirus	71.8	80.3	40.0	71.8	44.0
Hepatitis-A virus	0.9	0.8	0.8	0.6	0.6
Hepatitis-E virus	2.8	2.4	6.0	8.5	8.4
Cryptosporidium spp.	8.8	13.8	13.2	21.9	25.2
Giardia spp.	16.3	16.1	16.1	16.0	15.8
Toxoplasma gondii	15.5	15.1	15.4	15.0	14.9
Total	**446.1**	**434.5**	**393.5**	**434.6**	**430.1**

a) The estimates that are presented here for 2012-2015 cannot be compared with earlier estimates due to: a) new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp.; and b) the use of new reference prices (see Table A.3 in Annex I) and a shorter friction period (i.e. 12 weeks vs 26 weeks).

*Table A.8 – Attribution of mean incidence by pathogen to main pathways in the Netherlands, 2016**

Main pathway	**Food**	**Environment**	**Human**	**Animal**	**Travel**	**Total**
Campylobacter spp.	33,167	16,267	4,975	15,083	9,476	78,968
STEC O157	863	368	218	438	250	2,137
Salmonella spp.	17,556	4,155	2,996	2,964	4,542	32,212
Listeria monocytogenes	66	6	5	5	13	96
B. cereus toxine	46,542	573	625	573	3,805	52,119
C. perfringens toxine	154,245	3,754	3,583	3,583	5,460	170,625
S. aureus toxine	250,238	10,331	9,183	6,313	10,905	286,970
Norovirus	127,698	108,581	423,621	38,233	66,525	764,658
Rotavirus	17,890	23,395	79,956	4,129	12,248	137,618
Hepatitis-A virus	45	44	72	0	235	397
Hepatitis-E virus	257	464	142	201	799	1,863
Cryptosporidium spp.	12,958	30,162	29,835	14,591	21,342	108,888
Giardia spp.	10,833	19,915	28,915	8,916	14,749	83,328
Toxoplasma gondii	428	278	7	19	35	767
Total	**672,785**	**218,294**	**584,132**	**95,048**	**150,385**	**1,720,644**

* The ranking of pathogens has changed with previous reports due to new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp..

*Table A.9 – Attribution of mean deaths by pathogen to main pathways in the Netherlands, 2016**

Main pathway	**Food**	**Environment**	**Human**	**Animal**	**Travel**	**Total**
Campylobacter spp.	24.0	11.8	3.6	10.9	6.9	57.3
STEC O157	1.6	0.7	0.4	0.8	0.5	4.0
Salmonella spp.	17.6	4.2	3.0	3.0	4.6	32.4
Listeria monocytogenes	8.3	0.8	0.6	0.6	1.6	12.0
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	6.2	0.3	0.2	0.2	0.3	7.1
Norovirus	13.7	11.7	45.5	4.1	7.2	82.2
Rotavirus	2.9	3.8	13.2	0.7	2.0	22.6
Hepatitis-A virus	0.1	0.1	0.2	0.0	0.7	1.3
Hepatitis-E virus	3.0	5.3	1.6	2.3	9.2	21.5
Cryptosporidium spp.	0.8	1.9	1.8	0.9	1.3	6.7
Giardia spp.	0.3	0.6	0.8	0.2	0.4	2.3
Toxoplasma gondii	6.7	4.4	0.1	0.3	0.6	12.1
Total	**89.6**	**45.6**	**71.3**	**24.2**	**35.3**	**266.0**

* The ranking of pathogens has changed with previous reports due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp..

*Table A.10 – Attribution of mean disease burden (DALY per year, undiscounted) by pathogen to main pathways in the Netherlands, 2016**

Main pathway	**Food**	**Environment**	**Human**	**Animal**	**Travel**	**Total**
Campylobacter spp.	1,501	736	225	683	429	3,573
STEC O157	61	26	15	31	18	152
Salmonella spp.	757	179	129	128	196	1,389
Listeria monocytogenes	310	30	24	24	60	448
B. cereus toxine	28	0	0	0	2	32
C. perfringens toxine	177	4	4	4	6	196
S. aureus toxine	192	8	7	5	8	220
Norovirus	375	319	1,245	112	196	2,248
Rotavirus	88	114	391	20	60	673
Hepatitis-A virus	5	5	8	0	26	44
Hepatitis-E virus	102	184	56	80	317	738
Cryptosporidium spp.	22	51	51	25	36	185
Giardia spp.	29	53	77	24	39	221
Toxoplasma gondii	1,062	689	17	48	88	1,903
Total	**4,708**	**2,399**	**2,250**	**1,183**	**1,480**	**12,021**

* The ranking of pathogens has changed with previous reports due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.; and b) due to necessary model adaptations (i.e. new disability weights [9] (see Table A.2 in Annex I) and life tables (Table A.1 in Annex I)).

*Table A.11 – Attribution of mean cost-of-illness (M€ per year, discounted at 4% and expressed in 2016 euros) by pathogen to main pathways in the Netherlands, 2016**

Main pathway	**Food**	**Environment**	**Human**	**Animal**	**Travel**	**Total**
Campylobacter spp.	26.4	12.9	4.0	12.0	7.5	62.8
STEC O157	2.2	0.9	0.6	1.1	0.6	5.5
Salmonella spp.	11.6	2.7	2.0	2.0	3.0	21.2
Listeria monocytogenes	2.2	0.2	0.2	0.2	0.4	3.2
B. cereus toxine	9.5	0.1	0.1	0.1	0.8	10.7
C. perfringens toxine	25.6	0.6	0.6	0.6	0.9	28.3
S. aureus toxine	51.7	2.1	1.9	1.3	2.3	59.3
Norovirus	21.7	18.5	72.1	6.5	11.3	130.2
Rotavirus	5.7	7.5	25.6	1.3	3.9	44.0
Hepatitis-A virus	0.1	0.1	0.1	0.0	0.4	0.6
Hepatitis-E virus	1.16	2.1	0.64	0.91	3.6	8.4
Cryptosporidium spp.	3.0	7.0	6.9	3.4	4.9	25.2
Giardia spp.	2.1	3.8	5.5	1.7	2.8	15.8
Toxoplasma gondii	8.3	5.4	0.1	0.4	0.7	14.9
Total	**171.3**	**64.0**	**120.2**	**31.4**	**43.2**	**430.1**

* The ranking of pathogens has changed with previous reports due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.; and b) due to new reference prices (see Table A.3 in Annex I).

*Table A.12 – Attribution of mean incidence by pathogen to food groups in the Netherlands, 2016**

Food groups	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish& shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	1,360	1,692	17,877	1,028	2,952	2,322	1,758	564	763	1,095	1,758	33,167
STEC O157	381	55	27	18	64	25	61	31	25	30	146	863
Salmonella spp.	2,212	2,510	2,598	3,897	1,159	720	1,106	544	755	1,053	1,001	17,556
Listeria monocytogenes	7	6	4	3	16	12	5	2	4	4	3	66
B. cereus toxine	3,351	1,629	745	1,676	2,699	931	931	791	7,866	24,807	1,117	46,542
C. perfringens toxine	73,729	12,957	10,951	4,319	6,324	10,026	10,643	3,856	4,010	11,877	5,553	154,245
S. aureus toxine	18,768	20,269	19,519	8,258	36,785	14,514	5,005	4,504	18,768	74,070	29,778	250,238
Norovirus	4,086	3,959	3,703	2,426	2,554	19,793	9,322	3,959	6,640	6,385	64,871	127,698
Rotavirus	0	501	0	0	304	3,471	4,258	787	1,342	805	6,423	17,890
Hepatitis-A virus	0	0	0	0	0	6	6	2	2	1	28	45
Hepatitis-E virus	0	190	0	0	0	13	19	9	0	0	26	257
Cryptosporidium spp.	3,395	570	376	350	1,192	2,825	2,682	389	0	389	790	12,958
Giardia spp.	2,134	520	336	0	834	1,397	3,575	347	0	357	1,332	10,833
Toxoplasma gondii	98	215	21	0	20	16	25	0	0	10	24	428
Total	**109,521**	**45,073**	**56,156**	**21,974**	**54,903**	**56,069**	**39,395**	**15,785**	**40,175**	**120,883**	**112,851**	**672,785**

* The ranking of pathogens has changed with previous reports due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.

*Table A.13 – Attribution of mean deaths by pathogen to food groups in the Netherlands, 2016**

Food groups	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish& shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	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
Salmonella spp.	2.2	2.5	2.6	3.9	1.2	0.7	1.1	0.5	0.8	1.1	1.0	17.6
Listeria monocytogenes	0.9	0.8	0.5	0.3	2.1	1.5	0.6	0.2	0.5	0.5	0.4	8.3
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	1.8	0.7	6.2
Norovirus	0.4	0.4	0.4	0.3	0.3	2.1	1.0	0.4	0.7	0.7	7.0	13.7
Rotavirus	0.0	0.1	0.0	0.0	0.1	0.6	0.7	0.1	0.2	0.1	1.1	2.9
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	2.2	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.3	3.0
Cryptosporidium spp.	0.2	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.8
Giardia spp.	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3
Toxoplasma gondii	1.5	3.4	0.3	0.0	0.3	0.2	0.4	0.0	0.0	0.2	0.4	6.7
Total	**9.5**	**11.6**	**17.7**	**5.6**	**7.3**	**7.9**	**6.1**	**2.1**	**3.4**	**5.5**	**12.7**	**89.6**

* The ranking of pathogens has changed with previous reports due to: new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.

*Table A.14 – Attribution of mean disease burden (DALY per year, undiscounted) by pathogen to food groups in the Netherlands, 2016**

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish& shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter spp.	61.5	76.5	808.9	46.5	133.6	105.1	79.5	25.5	34.5	49.5	79.5	1,501
STEC O157	27.0	3.9	1.9	1.3	4.5	1.8	4.4	2.2	1.8	2.1	10.4	61
Salmonella spp.	95.4	108.2	112.0	168.1	50.0	31.0	47.7	23.5	32.6	45.4	43.1	757
Listeria monocytogenes	34.7	28.8	20.5	11.8	76.5	55.2	23.6	8.1	18.3	17.4	15.2	310
B. cereus toxine	2.0	1.0	0.5	1.0	1.6	0.6	0.6	0.5	4.8	15.1	0.7	28
C. perfringens toxine	84.7	14.9	12.6	5.0	7.3	11.5	12.2	4.4	4.6	13.7	6.4	177
S. aureus toxine	14.4	15.5	14.9	6.3	28.2	11.1	3.8	3.4	14.4	56.7	22.8	192
Norovirus	12.0	11.6	10.9	7.1	7.5	58.2	27.4	11.6	19.5	18.8	190.7	375
Rotavirus	0.0	2.5	0.0	0.0	1.5	17.0	20.8	3.9	6.6	3.9	31.4	88
Hepatitis-A virus	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.2	0.2	0.2	3.1	5
Hepatitis-E virus	0.0	75.3	0.0	0.0	0.0	5.0	7.5	3.6	0.0	0.0	10.5	102
Cryptosporidium spp.	5.8	1.0	0.6	0.6	2.0	4.8	4.6	0.7	0.0	0.7	1.3	22
Giardia spp.	5.6	1.4	0.9	0.0	2.2	3.7	9.5	0.9	0.0	0.9	3.5	29
Toxoplasma gondii	243.1	533.0	51.0	0.0	48.8	39.3	61.6	0.0	0.0	24.4	60.5	1,062
Total	**586.4**	**873.6**	**1,034.7**	**247.7**	**363.8**	**344.8**	**303.8**	**88.5**	**137.2**	**248.8**	**479.2**	**4,708**

* The ranking of pathogens has changed with previous reports due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.; and b) due to necessary model adaptations (i.e. new disability weights [9] (see Table A.2 in Annex I) and life tables (Table A.1 in Annex I)).

*Table A.15 – Attribution of mean cost-of-illness (Million € per year, discounted at 4% and expressed in 2016 euros) by pathogen to food groups in the Netherlands, 2016**

Food groups	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish& shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	1.1	1.3	14.2	0.8	2.3	1.8	1.4	0.4	0.6	0.9	1.4	26.4
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
Salmonella spp.	1.5	1.7	1.7	2.6	0.8	0.5	0.7	0.4	0.5	0.7	0.7	11.6
Listeria monocytogenes	0.2	0.2	0.1	0.1	0.5	0.4	0.2	0.1	0.1	0.1	0.1	2.2
B. cereus toxine	0.7	0.3	0.2	0.3	0.6	0.2	0.2	0.2	1.6	5.1	0.2	9.5
C. perfringens toxine	12.2	2.2	1.8	0.7	1.1	1.7	1.8	0.6	0.7	2.0	0.9	25.6
S. aureus toxine	3.9	4.2	4.0	1.7	7.6	3.0	1.0	0.9	3.9	15.3	6.2	51.7
Norovirus	0.7	0.7	0.6	0.4	0.4	3.4	1.6	0.7	1.1	1.1	11.0	21.7
Rotavirus	0.0	0.2	0.0	0.0	0.1	1.1	1.4	0.3	0.4	0.3	2.1	5.7
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	0.9	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	1.2
Cryptosporidium spp.	0.8	0.1	0.1	0.1	0.3	0.7	0.6	0.1	0.0	0.1	0.2	3.0
Giardia spp.	0.4	0.1	0.1	0.0	0.2	0.3	0.7	0.1	0.0	0.1	0.3	2.1
Toxoplasma gondii	1.9	4.2	0.4	0.0	0.4	0.3	0.5	0.0	0.0	0.2	0.5	8.3
Total	**24.4**	**16.1**	**23.3**	**6.8**	**14.4**	**13.4**	**10.3**	**3.8**	**9.0**	**25.8**	**24.0**	**171.3**

* The ranking of pathogens has changed with previous reports due to: a) new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp.; and b) due to new reference prices (see Table A.3 in Annex I).

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