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

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RIVM Letter report 2018-0037
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Colophon

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Synopsis

Disease burden of food-related pathogens in the Netherlands, 2017

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 12,000 DALYs in 2016 to 11,000 DALYs in 2017. The share of foodborne transmission in this estimated burden was comparable with earlier years, mounting to 4,200 DALYs in 2017. The total COI caused by the 14 pathogens decreased slightly from 436 €M in 2016 to 391 €M in 2017. The food-related COI was with 163 M€ in 2017, which is slightly lower than in 2016 (i.e. 173 €M). The differences in DALYs and COI between 2016 and 2017 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 number of incident cases 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.

Publiekssamenvatting

Ziektelast van via voedsel overdraagbare ziekteverwekkers in Nederland in 2017

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 dat verloren gaat aan ziekte of vroegtijdig overlijden. Het aantal DALY's als gevolg van de 14 ziekteverwekkers, via voedsel, is in 2017 geschat op 4.200, en is daarmee iets lager dan in 2016 (4.700 DALY's).

Ook kosten die aan deze ziekteverwekkers verbonden zijn, zijn lager: 163 miljoen euro in plaats van 173 miljoen euro in 2016. Deze *cost of illness* omvatten directe medische kosten, maar ook de kosten voor de patiënt en/of zijn familie, zoals reiskosten, en de kosten binnen andere sectoren, bijvoorbeeld door werkverzuim.

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 11.000 DALY's, en is daarmee lager dan in 2016 (12.000 DALY's). De totale kosten zijn geschat op 391 miljoen euro en waren daarmee lager dan in 2016 (436 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 daadwerkelijke aantal voedselinfecties dat mensen jaarlijks oplopen, de bijbehorende ziektelast en de blootstellingsroutes.

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

Contents

1 Introduction

Since 2008, RIVM regularly publishes estimates of the number of incident cases, disease burden and costs-of-illnesses of food-related disease on its web pages[1] and since 2010 in publicly available reports (e.g. [1-7]).

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 [8], and in the report from 2017 [6], when estimates were updated by using available RIVM laboratory surveillance data 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 more recent life expectancy tables from the Global burden of disease (GBD) 2010 study [10]. The COI, expressed in euros for all 14 food-related pathogens, was calculated for the first time in 2011 [11] and equally updated in 2017 using more recent reference prices for health economic evaluations from the Dutch healthcare institute [12, 13]. The economic module was integrated to the existing disease burden model in 2011, and annual updates of both, disease burden and COI have followed [3-7].

In the current report, trend information from surveillance, demographic information and consumer price index (a measure for changes in price levels of consumer goods and services) were used to update the information to the year 2017.

[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, 2013-2017

Age group	2017	2016	2015	2014	2013
0	172,288	170,341	174,681	170,953	175,587
1-4	700,001	706,513	713,641	726,716	736,615
5-11	1,307,281	1,313,978	1,324,894	1,338,448	1,354,657
12-17	1,224,528	1,225,749	1,215,977	1,206,685	1,196,634
18-64	10,517,749	10,477,231	10,463,848	10,467,463	10,491,7378
65+	3,159,660	3,085,308	3,007,685	2,919,024	2,824,345
Total	17,081,507	16,979,120	16,900,726	16,829,289	16,779,575

Table 2. Live births by age of mothers in the Netherlands, 2013-2017

Age of mother	2017*	2016	2015	2014	2013
-19	954	1,076	1,109	1,276	1,360
20-24	11,673	12,580	13,125	14,213	14,581
25-29	47,446	48,557	48,724	50,307	49,342
30-34	67,058	67,760	66,373	68,120	65,925
35-39	35,765	35,205	34,070	33,797	32,939
40-44	6,776	6,922	6,733	7,046	6,836
45+	404	420	376	422	358
Total	170,076	172,520	170,510	175,181	171,341

* Estimates based on observed trend from 2014-2016

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;
- Perinatal and acquired listeriosis: mandatory notification and active laboratory surveillance;
- Norovirus: estimated norovirus-associated hospitalized cases derived from RIVM laboratory surveillance;
- Rotavirus: RIVM laboratory surveillance;
- Hepatitis-A virus: mandatory notification and active laboratory surveillance;
- Hepatitis-E virus*:* RIVM laboratory surveillance data; Note this was adapted in 2017 [7] and is therefore different with earlier publications [1-6, 8, 11] where a stable incidence based on Borgen et al. [14] was assumed.
- *Cryptosporidium* spp.: RIVM laboratory surveillance data since 2013. Note this was adapted in 2017 [7] and is therefore

[2] https://opendata.cbs.nl/statline/#/CBS/nl/; accessed February 6th 2018

different with earlier publications [1-6, 8, 11] 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.). Note this was adapted in 2017 [7] and is therefore different with earlier publications [1-6, 8, 11] 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 cause (ICD codes 20-93; 558.9) were obtained from the Dutch Hospital Data (DHD) for 2011-2014. Since 2015 the number of hospitalized patients is 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 method for DALY calculations was not changed since last year (i.e. the 2017-updates) [7].

2.3 Cost of illness

The method for COI estimates was not changed since the 2017-updates [7], only the cost prices used for the different resources had to be updated to 2017 euros using consumer price indexes as provided by Statistics Netherlands[3]. In order to allow comparison with earlier results we also updated the earlier cost-of-illness estimates (i.e., 2012- 2016) to 2017 euros; hence all differences in the results for the year 2017 compared to earlier years will reflect the impact of trends in the underlying information on demographics and pathogen incidence.

2.4 Attribution

The fraction of human cases of enterically transmitted illness by five major pathways (food, environment, direct animal contact, human–human transmission, and travel) and by 11 groups within the food pathway was estimated using structured expert elicitation and is described in detail in Havelaar et al. [15]. The method for attribution was not changed since then.

[3] https://opendata.cbs.nl/statline/#/CBS/nl

3 Results

3.1 Trend information

Trend information for specific pathogens is presented in Table 3. A summary of trends (in comparison with 2016) is discussed below:

- The incidence of campylobacteriosis (laboratory confirmed cases) decreased from 38 cases per 100,000 inhabitants in 2016 to 33 cases per 100,000 inhabitants in 2017, showing a continuously decreasing trend since 2011.
- The incidence of salmonellosis (laboratory confirmed cases) is with 9 cases per 100,000 inhabitants lower than in 2016 (11 per 100,000 inhabitants), but similar to the years 2013-2015.
- The incidence of cryptosporidiosis (laboratory confirmed cases) decreased from 12 per 100,000 in 2016 to 8 per 100,000 in 2017.
- The incidence of gastroenteritis by rotavirus (laboratory confirmed cases) increased by ~60% to 16 per 100,000 inhabitants (10 per 100,000 inhabitants in 2016). The biannual trend of a low epidemic year being followed by a high epidemic year, and observed since 2013, seems to continue.
- The incidence of gastroenteritis by norovirus (laboratory confirmed cases) was with 23 cases per 100,000 inhabitants lower than in earlier years (e.g. 33 per 100,000 in habitants in 2016 and 27 per 100,000 inhabitants in 2015).
- The incidence of acquired listeriosis (laboratory confirmed cases, active surveillance) increased from 89 cases in 2016 to 112 cases in 2017. This was the highest number of acquired listerisosis cases so far ever recorded. The recorded fatalities was with 10 comparable with last year (i.e. 8 in 2016).
- In 2017 the incidence of perinatal listeriosis (laboratory confirmed cases, active surveillance) was 3 cases with 2 fatalities. This was lower than in 2016, with 7 cases and 4 fatalities, but similar to earlier years (i.e. 2014-2015).
- The incidence of diseases caused by STEC O157 (laboratory confirmed cases, active surveillance) was 58 laboratory confirmed cases of which 23 were hospitalized. The number of STEC O157 cases is slightly lower than in 2016 (64 cases). The number of HUS cases was with 2 in 2017 slightly lower than in 2016 with 3 cases.
- The incidence of hepatitis-A virus (notified cases) was 374 reported cases and 90 hospitalized cases (of 368 known cases) far higher than in earlier years (~ 80 cases in 2016 and 2015). This sharp increase is mainly due to an international outbreak in men-having sex with men (approximately 275 cases of the 374 cases).
- With 2 cases per 100,000 inhabitants was the incidence of hepatitis-E virus (laboratory confirmed cases) lower than in 2016 and in 2015 (i.e. 3 cases per 100,000) but similar to 2014 (2 cases per 100,000 inhabitants).
- The number of patients that were admitted to the hospital due to GE was estimated to be 21,400 in 2017 and therefore slightly

higher than in 2016 (20,800). The observed increase in 2017 was mainly driven by the far higher number of rotavirus infections in 2017 compared to 2016.

Table 3. Trends in incidence per 100,000 inhabitants and reported cases, respectively, of food-related pathogens, 1999-2017

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	39	21		19	14					32				
2000	42	20		16	13					43				
2001	44	20		18	11					41				
2002	41	15		17	12					49				
2003	33	21		18	13					57				
2004	40	16		15	13					37				
2005	44	13		21	16	85	15	6		53				
2006	40	16		26	17	59	17	5	1	40		258	39	
2007	41	12		20	15	60	12	6	1	83		168	27	
2008	39	16		27	18	51	6	1	1	45		183	35	
2009	44	12		31	18	76	4	3	1	57	21	176	29	
2010	50	14		35	23	73	13	4	1	51	21	262	52	0.8
2011	51	12		24	21	79	4	9	1	65	18[d]	125	25	0.9
2012	49	21		20	26[c]	71	8	6	0	85	31[e]	121	28	1
2013	48	9	6	23	26[c]	76	7	3	0	90	36[f]	109	30	0.9
2014	48	9	6	9	25[c]	92	9	4	2	79	31[g]	105	23	2
2015	43	9	10	20	27[c]	69	15	3	1	76	27[h]	80	23	3
2016	38	11	12	10	33[c]	89	8	7	4	64	21[i]	81	22	3
2017	33	9	8	16	23[c]	112	10	3	2	58	23	374[j]	90[k]	2

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 whereby presented numbers are rounded: ≥10 to two significant numbers (e.g. 12.5 = 12) and <10 to 1 significant number (e.g. 0.89=0.9); 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; j) ~ 275 cases are (in)directly linked to an international outbreak in men-having sex with men; k) known for 368 of the 374 cases.

3.2 Number of incident cases

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 acute GE. The other four pathogens (i.e. *Listeria monocytogenes*; *Toxoplasma gondii*; hepatitis-A virus; hepatitis-E virus) cause other diseases (e.g. meningitis, sepsis, hepatitis). The estimated number of incident cases of gastroenteritis by pathogen in 2017 is presented in Table 4. The estimated number of incident cases of diseases by non-gastrointestinal pathogens in 2017 is presented in Table 5. The number of incident cases by the 14 pathogens for the years 2012-2017 is presented in Figure 1 and in Table A.1 in Annex I.

There was an overall decrease of the estimated total number of foodborne diseases due to the 14 pathogens from 1,720,000 in 2016 to 1,490,000 in 2017, a result mostly due to the lower number of incident cases of norovirus and cryptosporidiosis, and to a lesser extend due to salmonellosis and campylobacteriosis in 2017 compared to 2016. The incident cases of gastroenteritis due to rotavirus increased. The estimated incidence of the remaining pathogens did not changed, mostly because no trend information based on surveillance data was available.

Table 4. Mean estimated number of incident cases and 95% uncertainty interval (between brackets) of gastroenteritis by pathogen in the Netherlands, 2017

Pathogen	Number of incident cases[#]			Fatal cases[#]
	General population (x 1,000)	GP visit (x 1,000)	Hospitalised (x 1,000)	
All causes	4830 (4000-5740)	223 (71-524)	21 -	NA#
Bacteria – infectious				
Campylobacter spp.	67 (9.2-185)	16 (7.9-30)	1.1 (0.4-2.2)	49 (32-69)
STEC O157	2.1 (0.2-8.9)	0.08 (0.02-0.3.1)	0.02 (0.02-0.02)	4 (2-7)
Salmonella spp.	27 (2.5-84)	4.1 (2.2-7.0)	1.1 (0.5-2.1)	34 (30-39)
Bacteria – toxin producing				
Bacillus cereus	53 (19-121)	7.3 (1.7-21)	0.2 (0.1-0.5)	0 -
Clostridium perfringens	171 (61-356)	31 (7.5-81)	0.3 (0.1-0.6)	5 (0-19)
Staphylococcus aureus	287 (134-518)	40 (12-94)	1.5 (0.6-2.8)	7 (0-28)
Viruses				
Norovirus	515 (354-738)	12 (6.8-19)	1.8 (1.0-3.2)	56 (24-110)
Rotavirus	209 (107-366)	13 (7.9-19)	5.4 (3.9-7.2)	35 (11-78)
Protozoa				
Cryptosporidium spp.	69 (24-170)	4.2 (2.0-7.5)	0.6 (0.2-1.2)	4 (0-19)
Giardia spp.	83 (46-156)	7.5 (3.9-13)	0.4 (0.04-1.4)	2 (0-9)

[#]Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.23=0.2). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table 5. Mean estimated number of incident cases and 95% uncertainty interval (between brackets) of non-gastrointestinal pathogen in the Netherlands, 2017

Pathogen	Number of incident cases *mean (95% CI)*		Fatal cases *mean (95% CI)*	
Listeria monocytogenes				
Perinatal	3	*	2	*
Acquired	112	*	10	*
Hepatitis-A virus[#]	1800	(1200-3000)	6	(4-10)
Hepatitis-E virus[#]	1300	(750-2000)	15	(5-32)
Toxoplasma gondii[#]				
Congenital	340	(180-600)	12	(8-19)
Acquired**	420	(200-720)	0	

*No uncertainty because *Listeria* cases were acquired through surveillance; ** chorioretinitis only. [#]The presented numbers are rounded: ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

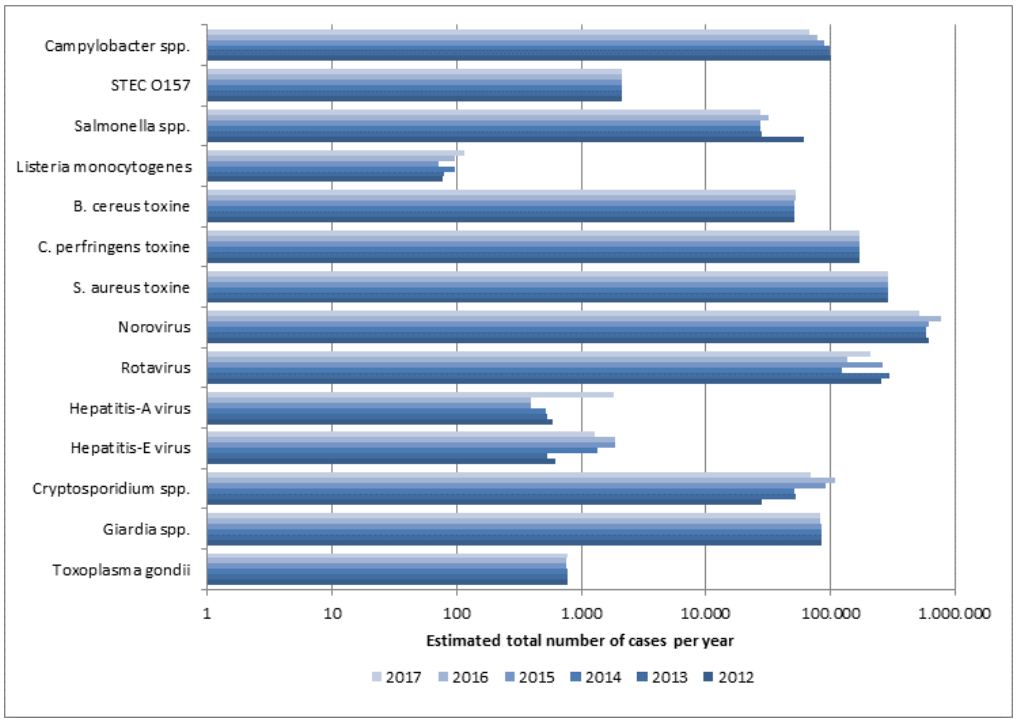

Figure 1. Comparison of mean estimated number of incident cases of food-related pathogens, 2012- 2017
* Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

The total number of deaths due to foodborne disease decreased from 270 in 2016 to 240 in 2017 (see Table A.2 in Annex).

3.3 Disease burden by pathogen

Table 6 presents the estimated burden of disease by pathogen for the year 2017 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 1,000 DALY from 12,000 DALY in 2016 (Table A.3 in Annex) to 11,000 in 2017, and is the year with the lowest disease burden in the past six years. Large differences in burden of disease between 2016 and 2017 were found for rotavirus (+420 DALYs), *Campylobacter* (-500 DALYs), norovirus (-640 DALYs), Hepatitis E virus (-230 DALY) and *Listeria* infections (-170 DALYs). The largest burden at population level was caused by *Campylobacter* spp. (3,100 DALY) and *Toxoplama gondii* (1,900 DALYs) followed by Norovirus (1,600 DALYs). Perinatal listeriosis was the disease outcome with the highest individual burden among all pathogens (60 DALY per case), followed by congenital toxoplasmosis (5 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, 2017[#]

Pathogen	DALY/year		DALY per 100,000/year		DALY per case	
Discount rate	0%	1.5%	0%	1.5%	0%	1.5%
Bacteria – infectious						
Campylobacter spp.	3,100	2,700	18	16	0.05	0.04
STEC O157	150	120	0.9	0.7	0.07	0.06
Salmonella spp.	1,200	1,100	7	6	0.05	0.04
L. monocytogenes (perinatal)	180	100	1	0.6	60	34
L. monocytogenes (acquired)	96	91	0.6	0.5	0.9	0.8
L. monocytogenes (total)	280	190	2	1	2	2
Bacteria – toxin producing						
Bacillus cereus	32	32	0.2	0.2	0.001	0.001
Clostridium perfringens	200	190	1	1	0.001	0.001
Staphylococcus aureus	220	210	1	1	0.001	0.001
Viruses						
Norovirus	1,600	1,400	9	8	0.003	0.003
Rotavirus	1,100	960	6	6	0.005	0.005
Hepatitis-A virus	200	160	1	0.9	0.1	0.09
Hepatitis-E virus	510	410	3	2	0.4	0.3
Protozoa						
Cryptosporidium spp.	120	110	0.7	0.7	0.002	0.002
Giardia spp.	220	220	1	1	0.003	0.003
Toxoplasma gondii (congenital)	1,600	920	9	5	5	3
Toxoplasma gondii (acquired)	280	210	2	1	0.7	0.5
Toxoplasma gondii (total)	1,900	1,100	11	7	2	1
TOTAL	11,000	9,000	64	53		

[#]Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

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 37% and YLL 50% of the total disease burden. The distribution between the different categories varied between pathogens, see Figure 2 for details.

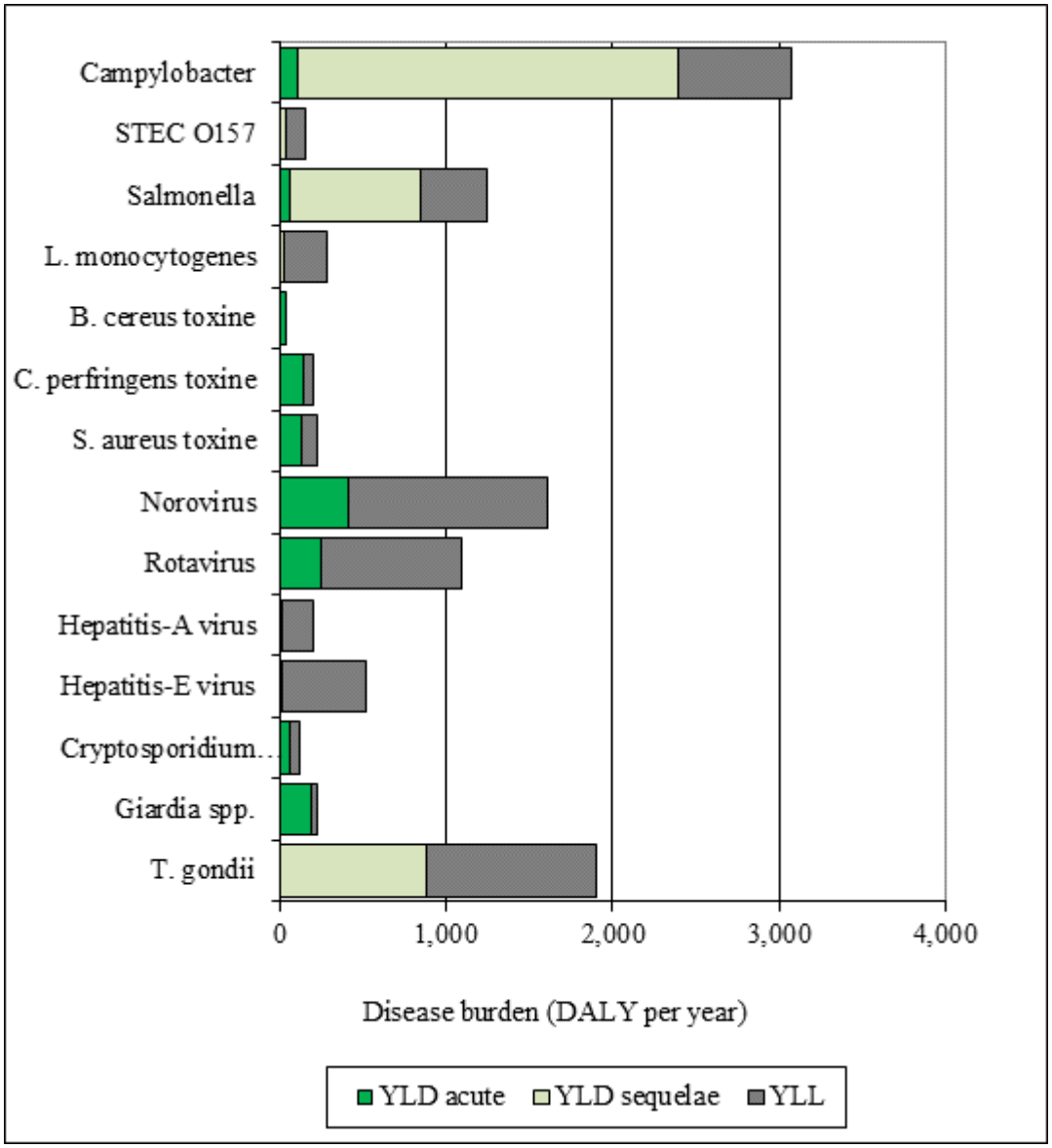

Figure 2. Mean DALY per year of food-related pathogens in 2017, split up into YLD associated with acute infections; YLD associated with sequelae and YLL.

The mean disease burden by the 14 pathogens for the years 2012-2017 is presented in Figure 3 and in Table A.3 in Annex.

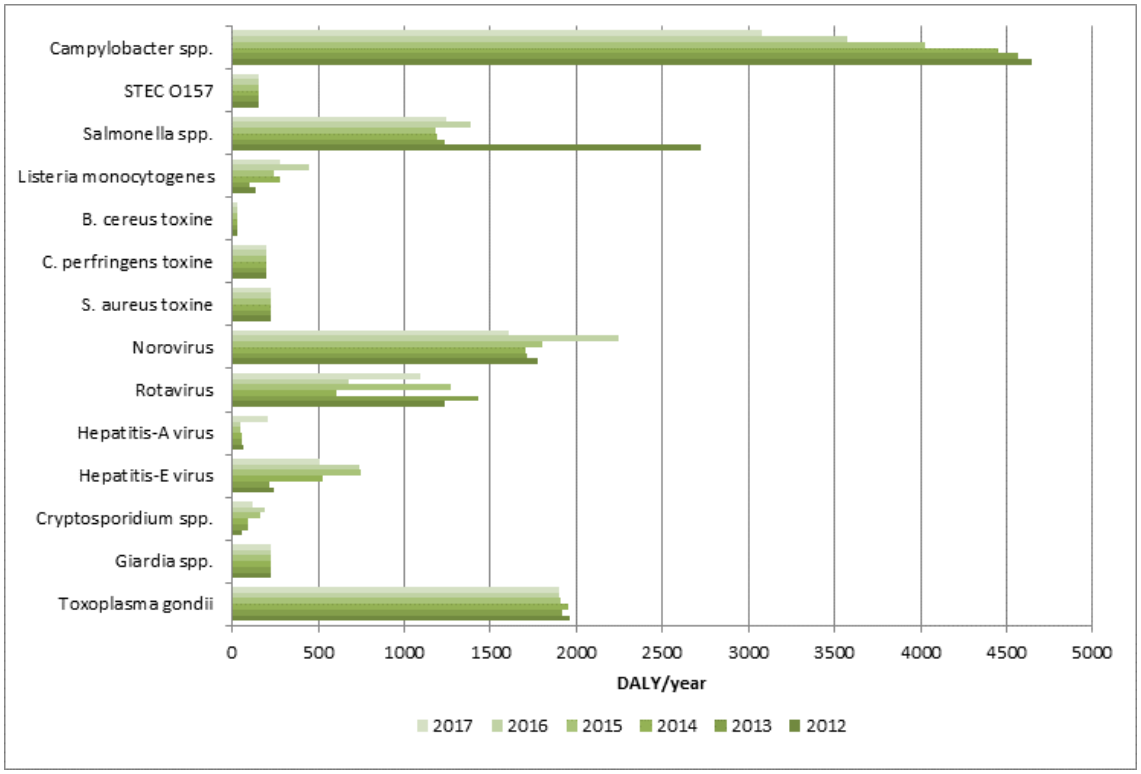

Figure 3. Comparison of disease burden (undiscounted DALYs) of food-related pathogens in 2012-2017

* Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. and new disability weights are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

3.4 Cost-of-illness by pathogen

The total COI was 45 €M lower in 2017 compared to 2016 (see Table A.4 in Annex) and was estimated at 391 M€ (discounted at 4%) in 2017 (Table 7 and Figures 4-5). The three pathogens causing the largest COI are norovirus (90 M€), rotavirus (61 M€) and GE due to *Staphylococcus aureus* toxin (60 M€). The lowest contribution to the COI was by hepatitis-A virus (2.9 M€). Predominated changes compared to 2016 were for norovirus (-41 M€), rotavirus (+16 M€), *Campylobacter* spp. (-9 M€), and *Cryptosporidium* spp. (-8 M€). The average cost per case were largest for perinatal *Listeria monocytogenes* infections (€116,000/case).

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, 2017

Pathogen	COI/year (M€)*		COI per 100,000 (k€)*		COI per case (€)*	
Discount rate	0%	4%	0%	4%	0%	4%
Bacteria – infectious						
Campylobacter spp.	59	55	348	321	880	820
STEC O157	11	5.5	64	32	5,100	2,600
Salmonella spp.	21	19	122	113	760	710
L. monocytogenes (perinatal)	0.9	0.3	5	2	294,000	116,000
L. monocytogenes (acquired)	3.0	2.8	17	16	27,000	25,000
L. monocytogenes (total)	3.9	3.1	23	18	34,000	27,000
Bacteria – toxin producing						
Bacillus cereus	11	11	64	64	210	210
Clostridium perfringens	29	29	169	169	170	170
Staphylococcus aureus	60	60	351	351	210	210
Viruses						
Norovirus	90	90	529	529	180	180
Rotavirus	61	61	355	355	290	290
Hepatitis-A virus	2.9	2.9	17	17	1,600	1,600
Hepatitis-E virus	5.8	5.8	34	34	4,600	4,600
Protozoa						
Cryptosporidium spp.	17	17	101	101	250	250
Giardia spp.	16	16	94	94	190	190
Toxoplasma gondii (congenital)	44	14	257	82	128,000	41,000
Toxoplasma gondii (acquired)	1.2	1.2	7	7	2,700	2,700
Toxoplasma gondii (total)	45	15	264	89	59,000	20,000
TOTAL	**433**	**391**	**2530**	**2290**		

* Total COI per year are presented in million € (M€) and if less than 1 million rounded to 1 significant number (e.g. 0.0023 million =0.002). COI per 100,000 and COI per case are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000 or 123 k€); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300 or 1.3 k€). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

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 23% of the total costs for the 14 pathogens, patient/family costs for 2% and costs in other sectors accounted for 75%. The distribution between the different cost categories varied between pathogens, as can be seen in Figure 4.

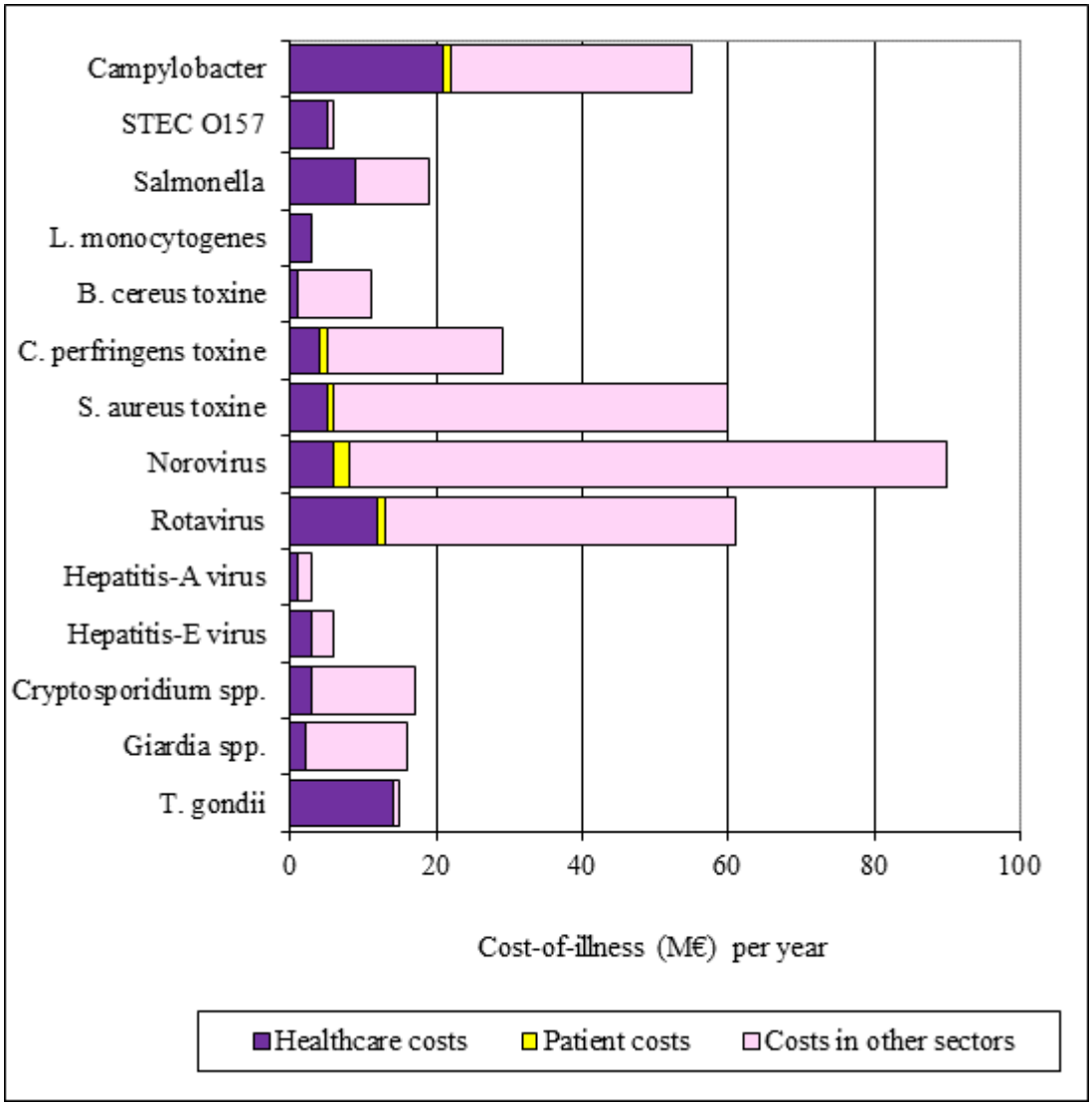

Figure 4. Mean cost-of-illness (discounted) per year of food-related pathogens in 2017, split up into healthcare costs, patient costs and costs in other sectors.

The mean COI estimates by the 14 pathogens for the years 2012-2017 is presented in Figure 3 and in Table A.4 in Annex.

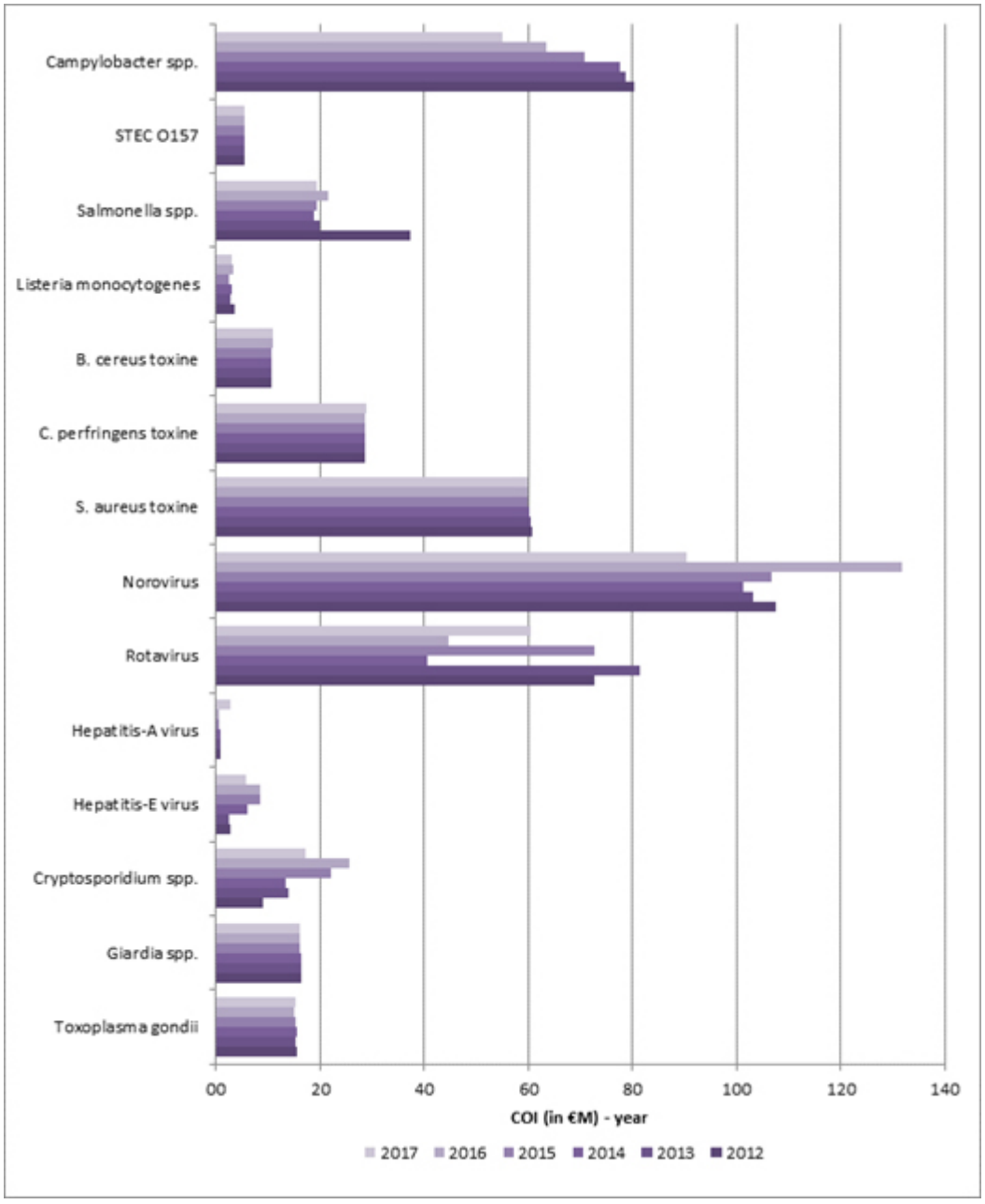

*Figure 5. Comparison of cost-of-illness (M€, discounted at 4% and expressed in 2017 euros) of food-related pathogens in 2012-2017**

* Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. and new reference prices as well as a shorter friction period are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

3.5 Attribution

The attribution results (expert elicitation) for DALYs and COI of foodborne diseases in 2017 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.5–A.12 in Annex. Foodborne disease burden accounted for 39% of the total burden (i.e. 4,200 DALYs per year), and 42% of the total COI (i.e. 163 M€). About 54% of the foodborne burden was associated with meat (i.e. poultry, pork, beef & lamb). These foods

caused 32% 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 attribution results for incidence, number of fatal cases, DALYs and COI estimates of foodborne diseases for the years 2012-2017 are presented in Tables 10-13. There was an overall decrease in foodborne infections from 2016 to 2017. The foodborne disease burden decreased by 500 DALYs from 4,700 DALYs in 2016 to 4,200 DALYs in 2017 and the COI decreased by 10 M€ from 173 M€ in 2016 to 163 M€ in 2017.

Table 8 Attribution of the mean estimated number of incident cases, fatalities, disease burden and cost-of-illness of foodborne disease[a] to the major transmission pathways in the Netherlands, 2017

Main pathway	Food	Environment	Human	Animal	Travel	Total
Number of incident cases (per year) [b]	629,000	181,000	476,000	77,000	125,000	1,490,000
Number of fatal cases (per year) [b]	83	40	67	21	30	240
Disease burden (DALY, undiscounted)) [b]	4,200	2,200	2,200	1,000	1,300	11,000
Disease burden (DALY, discounted (1.5%)) [b]	3,400	1,700	1,900	870	1,100	9,000
Cost of illness (M€, undiscounted) [c]	185	70	108	30	40	433
Cost of illness (M€, discounted (4%)) [c]	163	57	107	27	38	391

a) Due to the 14 pathogens included in this study
b) Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).
c) Costs are expressed in 2017 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, 2017

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish& shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Number of incident cases (per year) [b]	107,000	43,000	52,000	20,000	53,000	50,000	37,000	15,000	39,000	119,000	94,000	629,000
Number of fatal cases (per year) [b]	9	11	16	6	7	7	6	2	3	5	11	83
Disease burden (DALY, undiscounted)) [b]	550	810	900	220	310	300	280	77	120	230	420	4,200
Disease burden (DALY, discounted (1.5%)) [b]	420	560	780	190	250	250	230	67	110	200	350	3,400
Cost of illness (M€, undiscounted)[c]	29	24	23	7	15	13	11	4	9	26	23	185
Cost of illness (M€, discounted (4%)) [c]	24	16	21	6	14	12	10	4	9	26	21	163

a) Due to the 14 pathogens included in this study
b) Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).
c) Costs are expressed in 2017 euros and in million € (M€).

Table 10 Attribution of mean incidence to food in the Netherlands for 2012-2017, total and by pathogen

Pathogen	**Incidence/year[a]**					
	2012[b]	**2013[b]**	**2014[b]**	**2015[b]**	**2016**	**2017**
Campylobacter spp.	43,000	42,000	41,000	37,000	33,000	28,000
STEC O157	860	860	860	860	860	860
Salmonella spp.	33,000	15,000	15,000	15,000	18,000	15,000
Listeria monocytogenes	50	55	66	50	66	80
B. cereus toxine	45,000	46,000	46,000	46,000	47,000	47,000
C. perfringens toxine	154,000	153,000	154,000	154,000	154,000	155,000
S. aureus toxine	254,000	253,000	252,000	251,000	250,000	251,000
Norovirus	103,000	99,000	98,000	103,000	128,000	86,000
Rotavirus	34,000	39,000	16,000	34,000	18,000	27,000
Hepatitis-A virus	68	61	59	45	45	55
Hepatitis-E virus	85	74	180	260	260	180
Cryptosporidium spp.	3,300	6,200	6,200	11,000	13,000	8,200
Giardia spp.	11,000	11,000	11,000	11,000	11,000	11,000
Toxoplasma gondii	440	430	430	430	430	430
Total	**682,000**	**665,000**	**640,000**	**663,000**	**673,000**	**629,000**

a) Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

b) Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

Table 11 Attribution of mean number of fatal cases to food in the Netherlands for 2012-2017, total and by pathogen

Pathogen	**Number of fatal cases /year**					
	2012[a]	**2013[a]**	**2014[a]**	**2015[a]**	**2016**	**2017**
Campylobacter spp.	33	32	30	27	24	21
STEC O157	2	2	2	2	2	2
Salmonella spp.	36	16	15	15	18	19
Listeria monocytogenes	6	5	8	11	8	8
B. cereus toxine	0	0	0	0	0	0
C. perfringens toxine	4	4	4	4	4	4
S. aureus toxine	6	6	6	6	6	6
Norovirus	10	10	10	11	14	9
Rotavirus	5	6	3	6	3	5
Hepatitis-A virus	0	0	0	0	0	0
Hepatitis-E virus	1	1	2	3	3	2
Cryptosporidium spp.	0	0	0	1	1	1
Giardia spp.	0	0	0	0	0	0
Toxoplasma gondii	7	7	7	7	7	7
Total	**111**	**90**	**88**	**93**	**90**	**83**

a)Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

Table 12 Attribution of mean disease burden (DALY per year, undiscounted) to food in the Netherlands for 2012-2017, total and by pathogen

Pathogen	**DALY(undiscounted)/year[a]**					
	2012[b]	**2013[b]**	**2014[b]**	**2015[b]**	**2016**	**2017**
Campylobacter spp.	2,000	1,900	1,900	1,700	1,500	1,300
STEC O157	60	61	61	61	61	61
Salmonella spp.	1,500	670	650	640	760	680
Listeria monocytogenes	90	68	190	170	310	190
B. cereus toxine	28	28	28	28	28	29
C. perfringens toxine	180	180	180	180	180	180
S. aureus toxine	190	190	190	190	190	190
Norovirus	300	290	280	300	380	270
Rotavirus	160	190	78	170	88	140
Hepatitis-A virus	7	7	6	5	5	6
Hepatitis-E virus	34	30	73	100	100	70
Cryptosporidium spp.	10	11	11	19	22	14
Giardia spp.	30	29	29	29	29	29
Toxoplasma gondii	1,100	1,100	1,100	1,100	1,100	1,100
Total	**5,600**	**4,700**	**4,700**	**4,600**	**4,700**	**4,200**

a) Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

b) Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

Table 13– Attribution of mean COI (M€/year discounted at 4% and expressed in 2017 euros) to food in the Netherlands for 2012-2017, total and by pathogen

Pathogen	**COI per year (4%)/year[a] (Million €, expressed in 2017 euros)**					
	2012[b]	**2013[b]**	**2014[b]**	**2015[b]**	**2016**	**2017**
Campylobacter spp.	34	33	33	30	27	23
STEC O157	2	2	2	2	2	2
Salmonella spp.	20	11	10	11	12	11
Listeria monocytogenes	2	2	2	2	2	2
B. cereus toxine	9	9	10	10	10	10
C. perfringens toxine	26	26	26	26	26	26
S. aureus toxine	53	53	53	52	52	52
Norovirus	18	17	17	18	22	15
Rotavirus	9	11	5	9	6	8
Hepatitis-A virus	0.1	0.1	0.09	0.07	0.07	0.3
Hepatitis-E virus	0.4	0.3	0.8	1	1	0.8
Cryptosporidium spp.	1	2	2	3	3	2
Giardia spp.	2	2	2	2	2	2
Toxoplasma gondii	9	9	9	8	8	8
Total	**187**	**177**	**171**	**174**	**173**	**163**

a) Total COI per year are presented in million € (M€) and if less than 1 million rounded to 1 significant number (e.g. 0.0023 million =0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

b) Since the 2017-update new incidence estimates for hepatitis-E virus, Cryptosporidium spp. and Giardia spp. and new reference prices as well as a shorter friction period are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

4 Discussion

Although we observed an increasing trend in number of incident cases, disease burden and cost-of-illness for rotavirus and hepatitis-A virus, the overall estimated disease burden of 14 enteric pathogens in 2017 is lower than in 2016 (11,000 DALYs versus 12,000 DALYs), in fact, netto, a continuing decrease since 2012. The share of foodborne transmission is about 40%, and decreased from 4,700 DALYs in 2016 to 4,200 DALYs in 2017, i.e. the lowest burden since 2012. 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 for example, the drop of norovirus-associated COI was in 2017 partly compensated by a sharp increase in rotavirus-associated costs-of-illnesses.

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6 Annex: Detailed results

Table A.1 – Mean number of incident cases by pathogen in the Netherlands, 2012-2017

Pathogen	Estimated mean number of incident cases/year[a]					
	2012[b]	**2013**[b]	**2014**[b]	**2015**[b]	**2016**	**2017**
Campylobacter spp.	102,000	100,000	98,000	89,000	79,000	67,000
STEC O157	2,100	2,100	2,100	2,100	2,100	2,100
Salmonella spp.	61,000	28,000	28,000	27,00	32,000	27,000
Listeria monocytogenes	77	79	96	72	96	115
B. cereus toxine	51,000	51,000	52,000	52,000	52,000	53,000
C. perfringens toxine	170,000	170,000	170,000	170,000	171,000	171,000
S. aureus toxine	291,000	290,000	288,000	288,000	287,000	287,000
Norovirus	617,000	592,000	585,000	615,000	765,000	515,000
Rotavirus	258,000	297,000	124,000	261,000	138,000	209,000
Hepatitis-A virus	590	530	510	390	400	1,800
Hepatitis-E virus	620	540	1,300	1,900	1,900	1,300
Cryptosporidium spp.	28,000	52,000	52,000	92,000	109,000	69,000
Giardia spp.	86,000	85,000	84,000	84,000	83,000	83,000
Toxoplasma gondii	780	770	780	770	770	770
Total	**1,670,000**	**1,670,000**	**1,490,000**	**1,680,000**	**1,720,000**	**1,490,000**

a) Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help). There is one exception, *Listeria monocytogenes* which are acquired through surveillance.

b) Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

Table A.2 – Mean number of fatal cases by pathogen in the Netherlands, 2012-2017

Pathogen	**Estimated mean number of fatal cases/year[a]**					
	2012[b]	**2013[b]**	**2014[b]**	**2015[b]**	**2016**	**2017**
Campylobacter spp.	78	77	72	65	57	49
STEC O157	4	4	4	4	4	4
Salmonella spp.	67	30	28	28	32	34
Listeria monocytogenes	8	7	11	16	12	12
B. cereus toxine	0	0	0	0	0	0
C. perfringens toxine	5	5	5	5	5	5
S. aureus toxine	7	7	7	7	7	7
Norovirus	60	59	60	65	82	56
Rotavirus	40	47	20	43	23	35
Hepatitis-A virus	2	2	2	1	1	6
Hepatitis-E virus	7	6	15	22	21	15
Cryptosporidium spp.	2	3	3	6	7	4
Giardia spp.	2	2	2	2	2	2
Toxoplasma gondii	13	12	12	12	12	12
Total	**290**	**260**	**240**	**280**	**270**	**240**

a) Presented numbers are rounded: ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help). There is one exception, *Listeria monocytogenes* which are acquired through surveillance.

b) Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

Table A.3 – Mean estimated disease burden (undiscounted DALY/year) in the Netherlands for the years 2012- 2017, total and by pathogen

Pathogen	**DALY(undiscounted)/year[a]**					
	2012[b]	**2013[b]**	**2014[b]**	**2015[b]**	**2016**	**2017**
Campylobacter spp.	4,600	4,600	4,500	4,000	3,600	3,100
STEC O157	150	150	150	150	150	150
Salmonella spp.	2,700	1,200	1,200	1,200	1,400	1,200
Listeria monocytogenes	140	98	280	240	450	280
B. cereus toxine	31	31	31	32	32	32
C. perfringens toxine	200	200	200	200	200	200
S. aureus toxine	220	220	220	220	220	220
Norovirus	1,800	1,700	1,700	1,800	2,200	1,600
Rotavirus	1,200	1,400	600	1,300	670	1,100
Hepatitis-A virus	65	59	57	43	44	200
Hepatitis-E virus	240	210	530	740	740	510
Cryptosporidium spp.	53	92	91	160	190	120
Giardia spp.	230	230	220	220	220	220
Toxoplasma gondii	2,000	1,900	2,000	1,900	1,900	1,900
Total	**14,000**	**12,000**	**12,000**	**12,000**	**12,000**	**11,000**

a) Presented numbers are rounded to two significant numbers (e.g. 1,325 = 1,300). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

b) Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. and new disability weights are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

Table A.4– Mean discounted COI (4%) in million euros in the Netherlands for 2012-2017, total and by pathogen

Pathogen	COI per year (4%)/year[a] (Million €, expressed in 2017 euros)					
	2012[b]	**2013[b]**	**2014[b]**	**2015[b]**	**2016**	**2017**
Campylobacter spp.	80	79	78	71	64	55
STEC O157	6	6	6	6	6	6
Salmonella spp.	37	20	19	19	21	19
Listeria monocytogenes	4	3	3	3	3	3
B. cereus toxine	11	11	11	11	11	11
C. perfringens toxine	29	29	29	29	29	29
S. aureus toxine	61	61	60	60	60	60
Norovirus	107	103	101	107	132	90
Rotavirus	73	81	41	73	45	61
Hepatitis-A virus	0.9	0.8	0.8	0.6	0.6	3
Hepatitis-E virus	3	2	6	9	8	6
Cryptosporidium spp.	9	14	13	22	26	17
Giardia spp.	17	16	16	16	16	16
Toxoplasma gondii	16	15	16	15	15	15
Total	**452**	**440**	**399**	**440**	**436**	**391**

a) COI per year are presented in million € (M€) and if less than 1 million rounded to 1 significant number (e.g. 0.0023 million =0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

b) Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. and new reference prices as well as a shorter friction period are used, why estimates presented here for 2012-2015 are different from the one presented in earlier publications (i.e. [3-6]).

Table A.5 – Attribution of mean estimated number of incident cases by pathogen to main pathways in the Netherlands, 2017 [a]

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	28,000	14,000	4,200	13,000	8,100	67,000
STEC O157	860	370	220	440	250	2,140
Salmonella spp.	15,000	3,500	2,600	2,500	3,900	27,000
Listeria monocytogenes	80	8	6	6	15	120
B. cereus toxine	47,000	580	630	580	3,800	53,000
C. perfringens toxine	155,000	3,800	3,600	3,600	5,500	171,000
S. aureus toxine	251,000	10,000	9,000	6,300	11,000	287,000
Norovirus	86,000	73,000	285,000	26,000	45,000	515,000
Rotavirus	27,000	35,000	121,000	6,300	19,000	209,000
Hepatitis-A virus	55	54	1,400	0	290	1,800
Hepatitis-E virus	180	320	97	140	550	1,300
Cryptosporidium spp.	8,200	19,000	19,000	9,200	13,000	69,000
Giardia spp.	11,000	20,000	29,000	8,900	15,000	83,000
Toxoplasma gondii	430	280	7	19	35	770
Total	**629,000**	**181,000**	**476,000**	**77,000**	**125,000**	**1,490,000**

a) Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table A.6 – Attribution of mean estimated number of fatal cases to main pathways in the Netherlands, 2017 [a]

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	21	10	3	9	6	49
STEC O157	2	0.7	0.4	0.8	0.5	4
Salmonella spp.	19	4	3	3	5	34
Listeria monocytogenes	8	0.8	0.6	0.6	2	12
B. cereus toxine	0	0	0	0	0	0
C. perfringens toxine	4	0.1	0.1	0.1	0.1	5
S. aureus toxine	6	0.3	0.2	0.2	0.3	7
Norovirus	9	8	31	3	5	56
Rotavirus	5	6	21	1	3	35
Hepatitis-A virus	0.2	0.2	5	0	0.9	6
Hepatitis-E virus	2	4	1	2	6	15
Cryptosporidium spp.	0.5	1	1	0.6	0.8	4
Giardia spp.	0.3	0.6	0.8	0.2	0.4	2
Toxoplasma gondii	7	4	0.1	0.3	0.6	12
Total	**83**	**40**	**67**	**21**	**30**	**240**

a) Presented numbers are rounded: ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table A.7 – Attribution of mean disease burden (DALY per year, undiscounted) to main pathways in the Netherlands, 2017[a]

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	1,300	630	190	590	370	3,100
STEC O157	61	26	15	31	18	150
Salmonella spp.	680	160	120	110	170	1,200
Listeria monocytogenes	190	18	15	15	37	280
B. cereus toxine	29	0	0	0	2	32
C. perfringens toxine	180	4	4	4	6	200
S. aureus toxine	190	8	7	5	8	220
Norovirus	270	230	890	81	140	1,600
Rotavirus	140	190	640	33	98	1,100
Hepatitis-A virus	6	6	160	0	32	200
Hepatitis-E virus	70	130	39	55	220	510
Cryptosporidium spp.	14	33	33	16	23	120
Giardia spp.	29	53	76	24	39	220
Toxoplasma gondii	1,100	690	17	48	88	1,900
Total	**4,200**	**2,200**	**2,200**	**1,000**	**1,300**	**11,000**

a) Presented numbers are rounded: ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table A.8 – Attribution of mean cost-of-illness (M€ per year, discounted at 4% and in 2017 euros) to main pathways in the Netherlands, 2017

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	23	11	4	11	7	55
STEC O157	2	1	0.6	1	0.6	6
Salmonella spp.	11	3	2	2	3	19
Listeria monocytogenes	2	0.2	0.2	0.2	0.4	3
B. cereus toxine	10	0.1	0.1	0.1	0.8	11
C. perfringens toxine	26	0.6	0.6	0.6	0.9	29
S. aureus toxine	52	2	2	1	2	60
Norovirus	15	13	50	5	8	90
Rotavirus	8	10	35	2	5	61
Hepatitis-A virus	0.1	0.1	2	0.0	0.5	3
Hepatitis-E virus	0.8	2	0.4	0.6	3	6
Cryptosporidium spp.	2	5	5	2	3	17
Giardia spp.	2	4	6	2	3	16
Toxoplasma gondii	9	6	0.1	0.4	0.7	15
Total	**163**	**57**	**107**	**27**	**38**	**391**

a) COI per year are presented in million € (M€) and if less than 1 million rounded to 1 significant number (e.g. 0.0023 million =0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table A.9 – Attribution of mean incidence by pathogen to food groups in the Netherlands, 2017[a]

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish& shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter spp.	1,200	1,400	15,000	880	2,500	2,000	1,500	480	650	930	1,500	28,000
STEC O157	380	55	27	18	64	25	61	31	25	30	150	860
Salmonella spp.	1,900	2,100	2,200	3,300	990	610	940	460	640	900	850	15,000
Listeria monocytogenes	9	7	5	3	20	14	6	2	5	4	4	80
B. cereus toxine	3,400	1,600	750	1,700	2,700	940	940	800	7,900	25,000	1,100	47,000
C. perfringens toxine	74,000	13,000	11,000	4,300	6,400	10,000	11,000	3,900	4,000	12,000	5,600	155,000
S. aureus toxine	19,000	20,000	20,000	8,300	37,000	15,000	5,000	4,500	19,000	74,000	30,000	251,000
Norovirus	2,800	2,700	2,500	1,600	1,700	13,000	6,300	2,700	4,500	4,300	44,000	86,000
Rotavirus	0	760	0	0	460	5,300	6,500	1,200	2,000	1,200	9,700	27,000
Hepatitis-A virus	0	0	0	0	0	7	7	2	2	2	35	55
Hepatitis-E virus	0	130	0	0	0	9	13	6	0	0	18	180
Cryptosporidium spp.	2,100	360	240	220	750	1,800	1,700	250	0	250	500	8,200
Giardia spp.	2,100	520	330	0	830	1,400	3,600	350	0	360	1,300	11,000
Toxoplasma gondii	98	220	21	0	20	16	25	0	0	10	24	430
Total	**107,000**	**43,000**	**52,000**	**20,000**	**53,000**	**50,000**	**37,000**	**15,000**	**39,000**	**119,000**	**94,000**	**629,000**

a) Presented numbers are rounded: ≥ 100,000 to three significant numbers (e.g. 123,256 = 123,000); between <100,000 and ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table A.10 – Attribution of mean number of fatal cases by pathogen to food groups in the Netherlands, 2017[a]

Food groups	Beef & lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter spp.	0.8	1	11	0.6	2	1	1	0.4	0.5	0.7	1	21
STEC O157	0.7	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.3	2
Salmonella spp.	2	3	3	4	1	0.8	1	0.6	0.8	1	1	19
Listeria monocytogenes	0.9	0.8	0.5	0.3	2	1	0.6	0.2	0.5	0.5	0.4	8
B. cereus toxine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C. perfringens toxine	2	0.3	0.3	0.1	0.2	0.3	0.3	0.1	0.1	0.3	0.1	4
S. aureus toxine	0.5	0.5	0.5	0.2	0.9	0.4	0.1	0.1	0.5	2	0.7	6
Norovirus	0.3	0.3	0.3	0.2	0.2	1	0.7	0.3	0.5	0.5	5	9
Rotavirus	0.0	0.1	0.0	0.0	0.1	0.9	1	0.2	0.3	0.2	2	5
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	2	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.2	2
Cryptosporidium spp.	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	1
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	2	3	0.3	0.0	0.3	0.2	0.4	0.0	0.0	0.2	0.4	7
Total	**9**	**11**	**16**	**6**	**7**	**7**	**6**	**2**	**3**	**5**	**11**	**83**

a) Presented numbers are rounded: ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table A.11 – Attribution of mean disease burden (DALY per year, undiscounted) by pathogen to food groups in the Netherlands, 2017 [a]

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish& shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter spp.	53	66	700	40	115	90	68	22	30	43	68	1,300
STEC O157	27	4	2	1	5	2	4	2	2	2	10	61
Salmonella spp.	85	97	100	150	45	28	43	21	29	41	38	680
Listeria monocytogenes	21	18	13	7	47	34	14	5	11	11	9	190
B. cereus toxine	2	1	0.5	1	2	0.6	0.6	0.5	5	15	0.7	29
C. perfringens toxine	85	15	13	5	7	12	12	4	5	14	6	180
S. aureus toxine	14	16	15	6	28	11	4	3	14	57	23	190
Norovirus	9	8	8	5	5	42	20	8	14	13	140	270
Rotavirus	0	4	0	0	2	28	34	6	11	6	51	140
Hepatitis-A virus	0	0	0	0	0	0.8	0.8	0.3	0.3	0.2	4	6
Hepatitis-E virus	0	52	0	0	0	3	5	2	0	0	7	70
Cryptosporidium spp.	4	0.6	0.4	0.4	1	3	3	0.4	0	0.4	1	14
Giardia spp.	6	1	0.9	0	2	4	9	0.9	0	0.9	4	29
Toxoplasma gondii	240	530	51	0	49	39	62	0	0	24	61	1,100
Total	550	810	900	220	310	300	280	77	120	230	420	4,200

a) Presented numbers are rounded: ≥10 to two significant numbers (e.g. 1,325 = 1,300) and <10 to 1 significant number (e.g. 0.0023=0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).

Table A.12 – Attribution of mean cost-of-illness (M€ per year, discounted at 4% and expressed in 2017 euros) by pathogen to food groups in the Netherlands, 2017[a]

Food groups	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish& shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	0.9	1	12	0.7	2	2	1	0.4	0.5	0.8	1	23
STEC O157	1.0	0.1	0.07	0.05	0.2	0.06	0.2	0.08	0.06	0.08	0.4	2
Salmonella spp.	1	2	2	2	0.7	0.4	0.7	0.3	0.5	0.6	0.6	11
Listeria monocytogenes	0.2	0.2	0.1	0.08	0.5	0.4	0.2	0.06	0.1	0.1	0.1	2
B. cereus toxine	0.7	0.3	0.2	0.4	0.6	0.2	0.2	0.2	2	5	0.2	10
C. perfringens toxine	13	2	2	0.7	1	2	2	0.7	0.7	2	0.9	26
S. aureus toxine	4	4	4	2	8	3	1	0.9	4	16	6	52
Norovirus	0.5	0.5	0.4	0.3	0.3	2	1	0.5	0.8	0.8	8	15
Rotavirus	0	0.2	0	0	0	2	2	0.3	0.6	0.4	3	8
Hepatitis-A virus	0	0	0	0	0	0.01	0.01	0.004	0.004	0.003	0.05	0.09
Hepatitis-E virus	0	0.6	0	0	0	0.04	0.06	0.03	0	0	0.08	0.8
Cryptosporidium spp.	0.5	0.1	0.1	0.1	0.2	0.4	0.4	0.1	0	0.1	0.13	2
Giardia spp.	0.4	0.1	0.1	0	0.2	0.3	0.7	0.1	0	0.1	0.3	2
Toxoplasma gondii	2	4.2	0.4	0.0	0.4	0.3	0.5	0.0	0	0.2	0.5	9
Total	24	16	21	6	14	12	10	4	9	26	21	163

a) *COI per year are presented in million € (M€) and if less than 1 million rounded to 1 significant number (e.g. 0.0023 million =0.002). The presented numbers are estimates that rely on annual surveillance data being corrected for: i) coverage (where applicable); ii) underdiagnosis and underreporting; and iii) under-ascertainment (i.e. being sick without requiring medical help).*

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