



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

Disease burden of food-related pathogens in the Netherlands, 2018

RIVM Letter report 2019-0086
R. Pijnacker et al.



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Colophon

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Publiekssamenvatting

Ziektelast van via voedsel overdraagbare ziekteverwekkers in Nederland in 2018

Het RIVM onderzoekt elk jaar hoeveel mensen ziek worden en overlijden door maag-darminfecties die zij via voedsel oplopen. Virussen, bacteriën of parasieten kunnen hier de oorzaak van zijn. Deze ziektelast wordt uitgedrukt in DALY's (Disability Adjusted Life Year). Dit is een internationale maat voor het aantal gezonde levensjaren dat verloren gaat aan ziekte of vroegtijdig overlijden.

De onderzochte 14 ziekteverwekkers kunnen niet alleen via voedsel aan de mens worden overgedragen (in totaal ongeveer 40 procent). Dat kan namelijk ook via het milieu (bijvoorbeeld via oppervlaktewater), via dieren, en van mens op mens.

Het verschilt per ziekteverwekker via welke van deze routes de meeste mensen ziek worden. Sommige ziekteverwekkers verspreiden zich vooral via voeding, zoals *Salmonella*. Voor andere ziekteverwekkers zijn andere routes belangrijker. Het rotavirus bijvoorbeeld wordt vooral van mens op mens overgedragen. Het totaal aantal DALY's als gevolg van deze 14 ziekteverwekker is in 2018 hetzelfde als in 2017 (11.000 DALY's). De ziektelast via voedsel is in 2018 geschat op 4.300 DALY's, en is daarmee bijna hetzelfde als in 2017 (4.200).

De totale kosten van deze ziektelast worden geschat op 426 miljoen euro, en zijn daarmee hoger dan in 2017 (397 miljoen). Deze *cost of illness* zijn de 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 kosten als gevolg van besmet voedsel zijn ook iets hoger: 171 miljoen euro in 2018 ten opzichte van 163 miljoen euro in 2017. De verschillen in DALY's en kosten zijn vooral een gevolg van schommelingen in het aantal infecties van de onderzochte ziekteverwekkers.

Het ministerie van VWS is de opdrachtgever van dit onderzoek. De resultaten geven handvatten om meer zicht te krijgen op de ziektelast en manieren waarop de Nederlandse bevolking aan voedselinfecties wordt blootgesteld. Ook worden de ontwikkelingen door de jaren heen duidelijk.

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

Synopsis

Disease burden of food-related pathogens in the Netherlands, 2018

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 in 2018 was similar to 2017 (both 11,000 DALYs). The share of foodborne transmission in this estimated burden was comparable with earlier years, mounting to 4,300 DALYs in 2018 (2017: 4,200 DALYs). The total COI caused by the 14 pathogens increased slightly from 397 M€ in 2017 to 426 M€ in 2018. The food-related COI was 171 M€ in 2018, which is slightly higher than in 2017 (i.e. 163 M€). The differences in DALYs and COI between 2017 and 2018 are largely due to fluctuations in the number of infections that occur per pathogen, 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. It 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.

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Introduction

Since 2008, RIVM regularly publishes estimates of the number of incident cases, disease burden and costs-of-illnesses of food-related infectious disease on its web pages¹ and since 2010 in publicly available reports (e.g.[1-8])

The health impact of foodborne pathogens 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 [9], and in the disease burden report of food-related pathogens over the year 2015 [6]. Since last year (reporting over 2017), estimates for Hepatitis-E virus and *Cryptosporidium* spp. were updated by using available RIVM laboratory surveillance data, no negative trend correction was applied for *Giardia* spp.. Moreover, newly available European disability weights by Haagsma et al. [10] were used as well as more recent life expectancy tables from the Global burden of disease (GBD) 2010 study [11]. The COI, expressed in euros for all 14 food-related pathogens, was calculated for the first time in 2011 [12] and equally updated in 2018 using more recent reference prices for health economic evaluations from the Dutch healthcare institute [13, 14]. The economic module was integrated to the existing disease burden model in 2011, and annual updates of both, disease burden and COI have followed [3-8].

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 2018.

¹ <https://www.staatvenz.nl/kerncijfers/voedselinfecties-aantal-verloren-gezonde-levensjaren>

1 Methods

1.1 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 Netherlands².

Table 1. Population in the Netherlands by age group, 2014-2018

Age group	2018	2017	2016	2015	2014
0	169,566	172,288	170,341	174,681	170,953
1-4	698,533	700,001	706,513	713,641	726,716
5-11	1,303,023	1,307,281	1,313,978	1,324,894	1,338,448
12-17	1,214,974	1,224,528	1,225,749	1,215,977	1,206,685
18-64	10,555,872	10,517,749	10,477,231	10,463,848	10,467,463
65+	3,239,116	3,159,660	3,085,308	3,007,685	2,919,024
Total	17,181,084	17,081,507	16,979,120	16,900,726	16,829,289

Table 2. Live births by age of mothers in the Netherlands, 2014-2018

Age of mother	2018*	2017	2016	2015	2014
-19	983	1,023	1,076	1,109	1,276
20-24	11,073	11,722	12,580	13,125	14,213
25-29	46,632	47,197	48,557	48,724	50,307
30-34	68,438	67,575	67,760	66,373	68,120
35-39	35,562	34,905	35,205	34,070	33,797
40-44	7,073	6,941	6,922	6,733	7,046
45+	520	473	420	376	422
Total	170,281	169,836	172,520	170,510	175,181

* Estimates based on observed trend from 2015-2017

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, 9, 12] where a stable incidence based on Borgen et al. [15] was assumed.
- *Cryptosporidium* spp.: RIVM laboratory surveillance data since 2013. Note this was adapted in 2017 [7] and is therefore different

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

with earlier publications [1-6, 9, 12] 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, 9, 12] 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 *Staphylococcus 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 on 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 based on mandatory notification to RIVM. 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).

1.2 Disease burden

The method for DALY calculations was not changed since last year (i.e. reporting over 2017) [7].

1.3 Cost of illness

The method for COI estimates was not changed since the 2018-updates (i.e. reporting over 2017) [7], only the cost prices used for the different resources had to be updated to 2018 euros using consumer price indexes as provided by Statistics Netherlands³. In order to allow comparison with earlier results we also updated the earlier cost-of-illness estimates (i.e., 2013-2017) to 2018 euros; hence all differences in the results for the year 2018 compared to earlier years will reflect the impact of trends in the underlying information on demographics and pathogen incidence.

1.4 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. [16]. The method and estimates for attribution was not changed since then.

³ <https://opendata.cbs.nl/statline/#/CBS/nl>

2 Results

2.1 Trend information

Trend information for specific pathogens is presented in Table 3. A summary of trends (in comparison with 2017) is discussed below:

- The incidence of campylobacteriosis (laboratory confirmed cases) increased from 33 cases per 100,000 inhabitants in 2017 to 35 cases per 100,000 inhabitants in 2018. However, the incidence in 2018 is lower compared with 2010-2016.
- The incidence of salmonellosis (laboratory confirmed cases) is with 9 cases per 100,000 inhabitants similar to 2013-2017 (range: 9 to 11 per 100,000 inhabitants).
- The incidence of cryptosporidiosis (laboratory confirmed cases) increased from 8 per 100,000 in 2017 to 10 per 100,000 in 2018, but is within the range of the incidence in 2013-2016.
- The incidence of gastroenteritis by rotavirus (laboratory confirmed cases) in 2018 (17 per 100,000 inhabitants) was similar to 2017 (16 per 100,000 inhabitants in 2017). The observed biannual trend of a low epidemic year followed by a high epidemic year that was observed in 2014-2017 did not continue in 2018.
- The incidence of gastroenteritis by norovirus (laboratory confirmed cases) was with 27 cases per 100,000 inhabitants higher than in 2017 (23 per 100,000 inhabitants) but similar to 2012-2016 (range: 25-33 per 100,000 inhabitants).
- The incidence of acquired listeriosis (laboratory confirmed cases, active surveillance) decreased from 112 cases in 2017 to 71 cases in 2018. It was also slightly lower than most years in 2013-2016. The recorded fatalities was with 4 also lower than previous years (e.g. 10 in 2017 and 8 in 2016).
- In 2018 the incidence of perinatal listeriosis (laboratory confirmed cases, active surveillance) was 7 cases with 2 fatalities. This was higher than in 2017, with 3 cases and 2 fatalities, but similar to earlier years (i.e. 2015-2016).
- The incidence of diseases caused by STEC O157 (laboratory confirmed cases, active surveillance) in 2018 was 59 laboratory confirmed cases of which 23 were hospitalized, which is similar to 2017 (58 cases) but lower compared to 2014 and 2015. The number of patients with HUS was with 5 cases in 2018 slightly higher than in 2014-2017 with 2 or 3 cases annually.
- The incidence of hepatitis-A virus (active surveillance) was 188 reported cases and 57 hospitalized cases far higher than in earlier years (~ 80 cases in 2016 and 2015), but lower than in 2017 (374 cases). The high number of cases in 2017 and 2018 was due to an international outbreak in men-having sex with men, which peaked in 2017 and decreased throughout 2018.
- With 2 cases per 100,000 inhabitants the incidence of hepatitis-E virus (laboratory confirmed cases) was lower than in 2016 and in 2015 (i.e. 3 cases per 100,000) but similar to 2017 (2 cases per 100,000 inhabitants).

- The number of patients that were admitted to the hospital due to GE was estimated to be 21,800 in 2018 and was similar to 2017 (21,400) and slightly higher than in 2016 (20,800). The lower number of hospitalizations in 2016 was mainly due to a lower number of rotavirus infections.

Table 3. Trends in incidence per 100,000 inhabitants and reported cases, respectively, of food-related pathogens, 1999-2018

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 ^k	90 ^m	2
2018	35	9	10	17	27 ^c	71	4	7	2	59	23 ^j	188 ^l	57 ⁿ	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 57/65 cases; e) known for 77/85 cases; f) known for 84/90 cases; g) known for 71/79 cases; h) known for 68/76 cases; i) known for 60/64 cases; j) known for 58 out of 59 cases; k) ~ 275 cases are (in)directly linked to an international outbreak in men-having sex with men (MSM); l) 65 cases are (in)directly linked to an international outbreak of MSM; m) known for 368/374 cases; n) known for 187/188 cases

2.2 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 gastroenteritis. 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 (acute) gastroenteritis by pathogen in 2018 is presented in Table 4. The estimated number of incident cases of diseases by non-gastrointestinal pathogens in 2018 is presented in Table 5. The number of incident cases by the 14 pathogens for the years 2013-2018 is presented in Figure 1 and in Table A.1 in Annex I.

There was an increase of the estimated total number of cases due to the 14 food-related pathogens from 1,490,000 in 2017 to 1,630,000 in 2018, a result mostly due to the higher number of incident cases of norovirus, and to a lesser extent due to cryptosporidiosis and rotavirus in 2018 compared with 2017. The estimated incidence of the remaining pathogens did not change, 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, 2018

Pathogen	Number of incident cases [#]			Fatal cases [#]
	General population (x 1,000)	GP visit (x 1,000)	Hospitalised (x 1,000)	
All causes	4,840 (4,010-5,760)	225 (71-529)	22 -	NA [#]
Bacteria – infectious				
<i>Campylobacter</i> spp.	71 (9.3-198)	17 (8.6-32)	1.1 (0.4-2.2)	47 (31-65)
STEC O157	2.1 (0.2-8.6)	0.3 (0.01-0.9)	0.02 (0.02-0.02)	4.0 (2-7)
<i>Salmonella</i> spp.	27 (2.2-81)	4.0 (2.1-6.8)	1.1 (0.5-2.1)	25 (22-29)
Bacteria – toxin producing				
<i>Bacillus cereus</i>	53 (19-126)	7,4 (1.7-21)	0,2 (0.1-0.5)	0 -
<i>Clostridium perfringens</i>	171 (63-355)	32 (7.5-82)	0.3 (0.1-0.6)	5 (0-20)
<i>Staphylococcus aureus</i>	288 (130-525)	40 (11-95)	1.5 (0.6-2.9)	7 (0-29)
Viruses				
Norovirus	615 (421-881)	14 (8.2-23)	1.9 (1-3.2)	69 (28-131)
Rotavirus	224 (115-393)	13 (8.5-20)	5.5 (4.1-7.4)	38 (12-85)
Protozoa				
<i>Cryptosporidium</i> spp.	91 (32-219)	6 (2.7-10)	0.6 (0.2-1.2)	6 (0-25)
<i>Giardia</i> spp.	82 (46-156)	8 (3.9-13)	0.4 (0.04-1.4)	2 (0-9)

[#]Presented numbers are rounded: $\geq 100,000$ 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 5. Mean estimated number of incident cases and 95% uncertainty interval (between brackets) of non-gastrointestinal pathogen in the Netherlands, 2018

Pathogen	Number of incident cases		Fatal cases	
	mean	(95% CI)	mean	(95% CI)
Listeria				
monocytogenes				
Perinatal	7	*	2	*
Acquired	71	*	4	*
Hepatitis-A virus [#]	900	(600-1,500)	3	(2-5)
Hepatitis-E virus [#]	1,300	(770-2,000)	15	(5-32)
Toxoplasma gondii[#]				
Congenital	343	(178-605)	12	(8-19)
Acquired ^{**}	427	(199-724)	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).

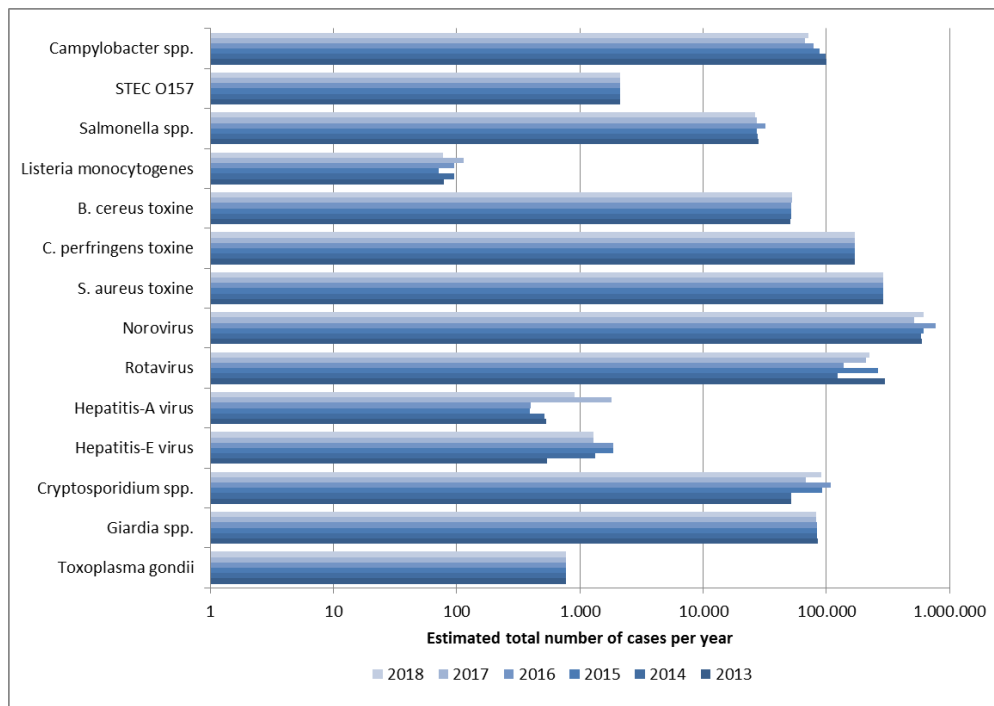


Figure 1. Comparison of mean estimated number of incident cases of food-related pathogens, 2013- 2018

* Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2013-2015 are different from the one presented in earlier publications (i.e. [3-6]).

The total number of estimated deaths due to foodborne disease in 2018 was similar to 2017, with 238 and 240 deaths, respectively (see Table A.2 in Annex).

2.3 Disease burden by pathogen

Table 6 presents the estimated burden of disease by pathogen for the year 2018 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 in 2018 was similar to 2017, with 11,000 DALYs, but lower than 2010-2016 (Table A.3 in Annex). The largest difference in burden of disease between 2017 and 2018 was found for norovirus (+330 DALYs). The largest burden at population level was caused by *Campylobacter* spp. (3,200 DALY), *Toxoplasma gondii* (1,900 DALYs) and norovirus (1,900 DALYs).

Interestingly, although the disease burden for *Campylobacter* spp. has continually decreased since 2010, the disease burden slightly increased in 2018. Perinatal listeriosis was the disease outcome with the highest individual burden among all pathogens (31 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, 2018[#]

Pathogen	DALY/year		DALY per 100,000/year		DALY per case	
	0%	1.5%	0%	1.5%	0%	1.5%
Bacteria – infectious						
<i>Campylobacter</i> spp.	3,200	2,800	19	16	0,04	0,04
STEC O157	150	120	0,9	0,7	0,07	0,06
<i>Salmonella</i> spp.	1,100	1,000	6,6	5,8	0,04	0,04
<i>L. monocytogenes</i> (perinatal)	220	120	1,3	0,7	31	18
<i>L. monocytogenes</i> (acquired)	42	39	0,2	0,2	0,6	0,6
<i>L. monocytogenes</i> (total)	260	160	1,5	1,0	3,3	2,1
Bacteria – toxin producing						
<i>Bacillus cereus</i>	32	32	0,2	0,2	0,001	0,001
<i>Clostridium perfringens</i>	200	190	1,1	1,1	0,001	0,001
<i>Staphylococcus aureus</i>	220	210	1,3	1,2	0,001	0,001
Viruses						
Norovirus	1,900	1,700	11,3	10,1	0,003	0,003
Rotavirus	1,200	1,040	6,9	6,1	0,005	0,005
Hepatitis-A virus	100	80	0,6	0,5	0,11	0,09
Hepatitis-E virus	510	410	3,0	2,4	0,4	0,3
Protozoa						
<i>Cryptosporidium</i> spp.	160	150	0,9	0,9	0,002	0,002
<i>Giardia</i> spp.	220	220	1,3	1,3	0,003	0,003
<i>Toxoplasma gondii</i> (congenital)	1,600	920	9,4	5,4	5	3
<i>Toxoplasma gondii</i> (acquired)	280	210	1,6	1,2	0,7	0,5
<i>Toxoplasma gondii</i> (total)	1,900	1,100	11	6,6	2,5	1
TOTAL	11,000	9,000	64	52		

[#] Presented numbers are rounded: $\geq 100,000$ 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 14% to the total disease burden; YLD associated with sequelae/residuals contributed 37% and YLL 49% of the total disease burden. The distribution between the different categories varied between pathogens, see Figure 2 for details.

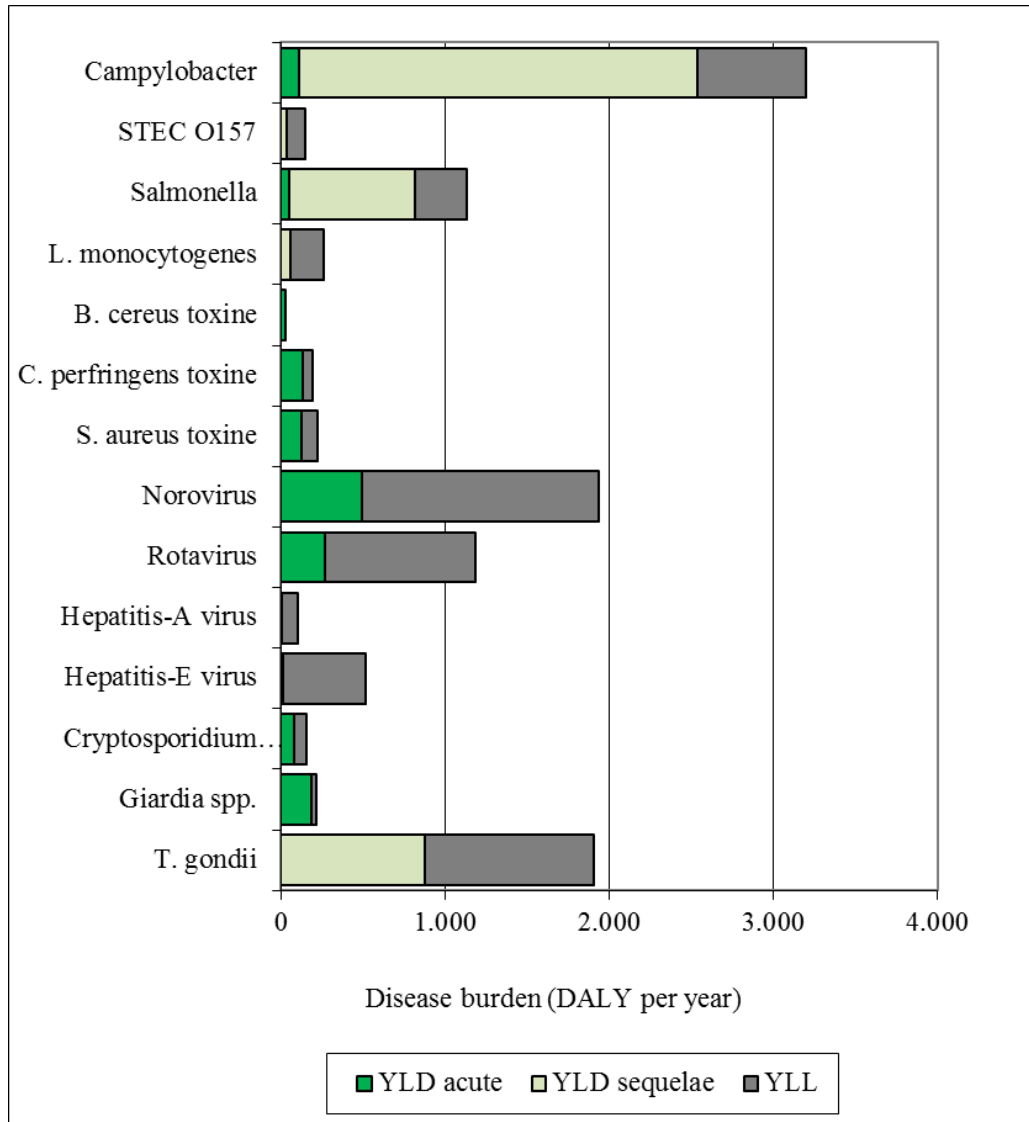


Figure 2. Mean DALY per year of food-related pathogens in 2018, split up into YLD associated with acute infections; YLD associated with sequelae and YLL.

The mean disease burden by the 14 pathogens for the years 2013-2018 is presented in Figure 3 and in Table A.3 in Annex.

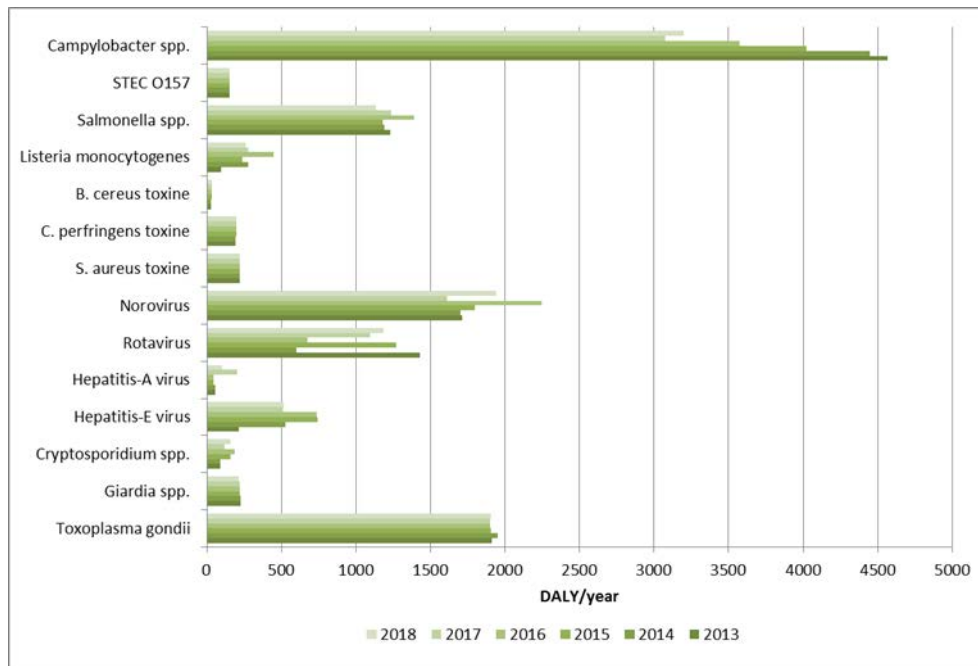


Figure 3. Comparison of disease burden (undiscounted DALYs) of food-related pathogens in 2013-2018

* Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. and new disability weights are used, therefore estimates presented here for 2013-2015 are different from the one presented in earlier publications (i.e. [3-6]).

2.4 Cost-of-illness by pathogen

The total COI in 2018 (425 M€; discounted at 4%) was higher than in 2017 (397 M€) but comparable with 2013-2016 (Table 7, Figures 4-5, and Annex Table A.4). The three pathogens causing the largest COI are norovirus (109 M€), rotavirus (66 M€), *Staphylococcus aureus* toxin (61 M€), and *Campylobacter* (60 M€). The lowest contribution to the COI was by hepatitis-A virus (1.5 M€). The most predominated change compared to 2017 was for norovirus (+17 M€). The average cost per case was largest for perinatal *Listeria monocytogenes* infections (€212,000/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, 2018

Pathogen	COI/year (M€)*		COI per 100,000 (k€)*		COI per case (€)*	
	0%	4%	0%	4%	0%	4%
Discount rate						
Bacteria – infectious						
<i>Campylobacter</i> spp.	64	60	375	346	900	840
STEC O157	11	5,6	64	33	5,200	2.700
<i>Salmonella</i> spp.	21	19	120	112	780	730
<i>L. monocytogenes</i> (perinatal)	4.2	1.5	24.5	8.7	601,000	212,000
<i>L. monocytogenes</i> (acquired)	1.9	1.8	11	10	27,000	25,000
<i>L. monocytogenes</i> (total)	6.1	3.3	36	19	78,000	42,000
Bacteria – toxin producing						
<i>Bacillus cereus</i>	11	11	65	65	210	210
<i>Clostridium</i> <i>perfringens</i>	29	29	171	171	170	170
<i>Staphylococcus aureus</i>	61	61	356	356	210	210
Viruses						
Norovirus	109	109	635	635	180	180
Rotavirus	66	66	383	383	290	290
Hepatitis-A virus	1.5	1.5	9	9	1,600	1,600
Hepatitis-E virus	6.0	6.0	35	35	4,600	4,600
Protozoa						
<i>Cryptosporidium</i> spp.	22	22	129	129	240	240
<i>Giardia</i> spp.	16	16	95	95	200	200
<i>Toxoplasma gondii</i> (congenital)	45	14	260	83	130,000	42,000
<i>Toxoplasma gondii</i> (acquired)	1.2	1.2	6.9	6.8	2,800	2,800
<i>Toxoplasma gondii</i> (total)	46	15	267	90	60,000	20,000
TOTAL	471	426	2,740	2,480		

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

* 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: $\geq 100,000$ 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 21% of the total costs for the 14 pathogens, patient/family costs for 2% and costs in other sectors accounted for 77%. The distribution between the different cost categories varied between pathogens.

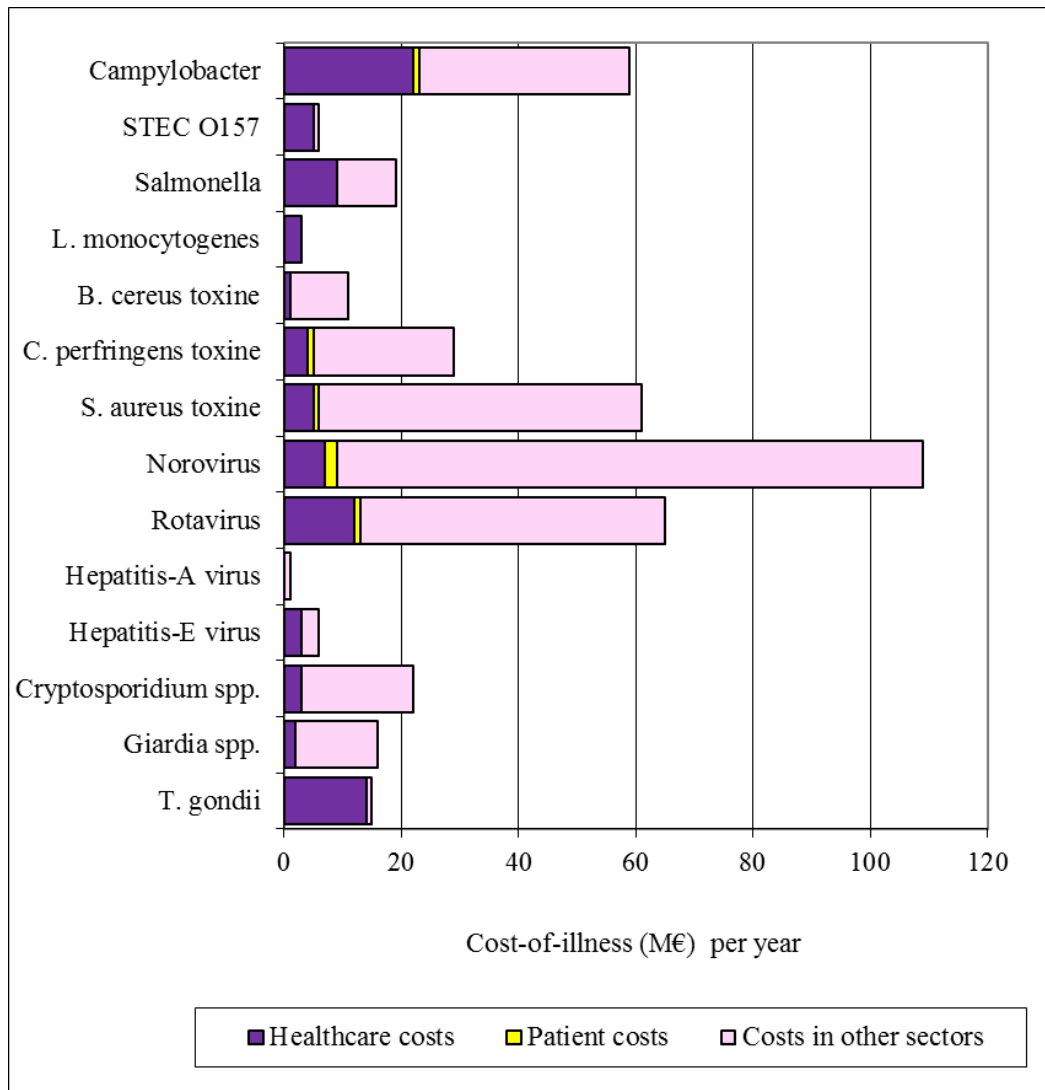


Figure 4. Mean cost-of-illness (discounted) per year of food-related pathogens in 2018, split up into healthcare costs, patient costs and costs in other sectors.

The mean COI estimates per pathogen for the years 2013-2018 is presented in Figure 5 and in Table A.4 in Annex.

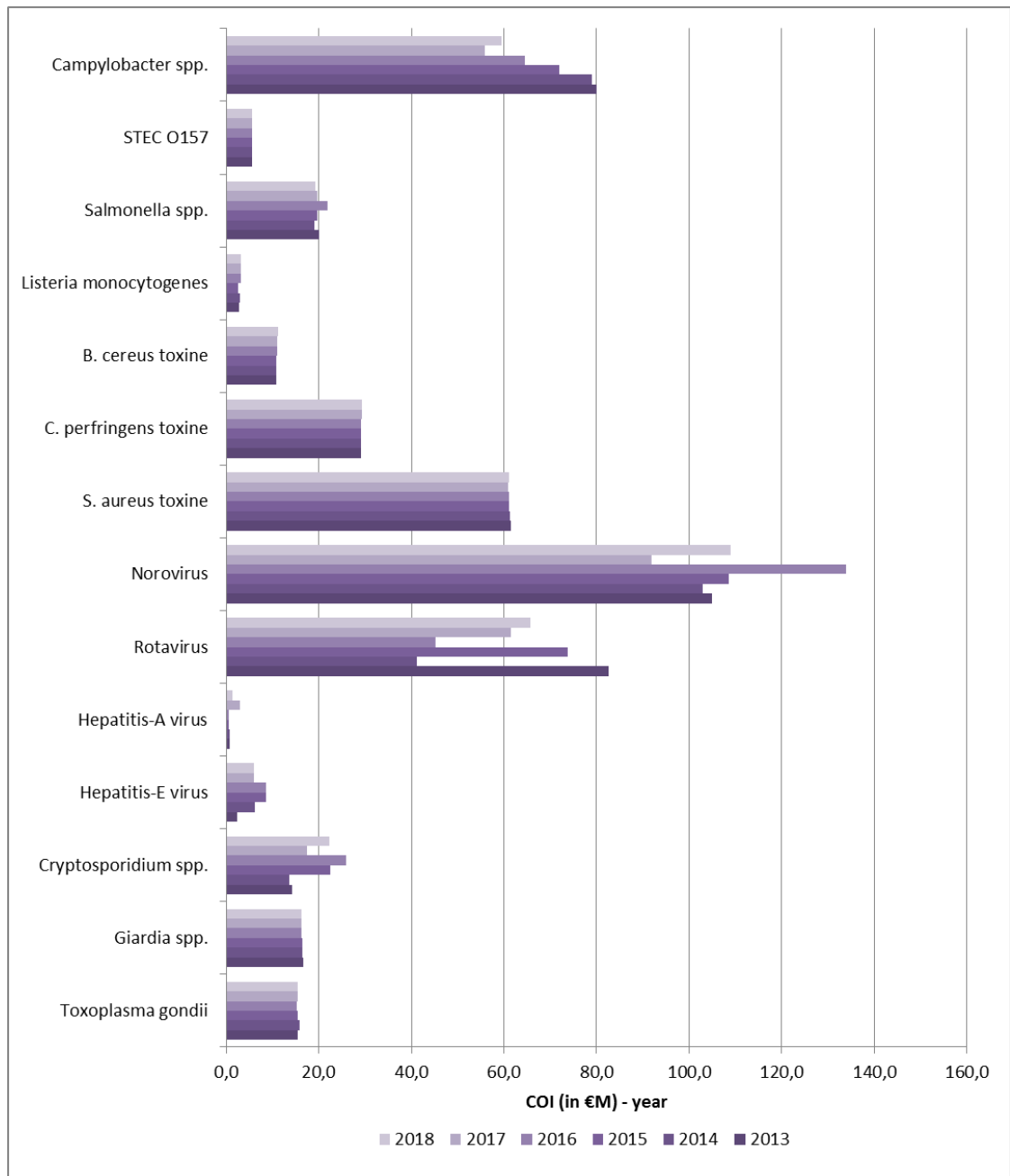


Figure 5. Comparison of cost-of-illness (M€, discounted at 4% and expressed in 2017 euros) of food-related pathogens in 2013-2018*

* 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, therefore estimates presented here for 2013-2015 are different from the one presented in earlier publications (i.e. [3-6]).

2.5 Attribution

The attribution results (expert elicitation) for DALYs and COI of foodborne diseases in 2018 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. 4,300 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 are considered 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 2013-2018 are presented in Tables 10-13. There was an overall increase in foodborne infections from 2017 to 2018. The foodborne disease burden slightly increased by 100 DALYs from 4,200 DALYs in 2017 to 4,300 DALYs in 2018 and the COI increased by 8 M€ from 163 M€ in 2017 to 171 M€ in 2018.

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, 2018

Main pathway	Food	Environment	Human	Animal	Travel	Total
Number of incident cases (per year) ^b	652,000	204,000	546,000	86,000	140,000	1,630,000
Number of fatal cases (per year) ^b	76	41	71	20	30	240
Disease burden (DALY, undiscounted) ^b	4,300	2,300	2,300	1,100	1,300	11,000
Disease burden (DALY, discounted (1.5%)) ^b	3,400	1,800	2,100	910	1,100	9,300
Cost of illness (M€, undiscounted) ^c	195	76	122	33	45	471
Cost of illness (M€, discounted (4%)) ^c	171	63	121	30	41	426

a) Due to the 14 pathogens included in this study

b) Presented numbers are rounded: $\geq 100,000$ 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 foodborne disease^a to food group in the Netherlands, 2018

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	108,000	44,000	53,000	21,000	54,000	54,000	39,000	15,000	40,000	120,000	104,000	652,000
Number of fatal cases (per year) ^b	8	10	14	4	6	7	6	2	3	5	12	76
Disease burden (DALY, undiscounted) ^b	550	810	920	210	310	310	290	78	120	230	450	4,300
Disease burden (DALY, discounted (1.5%)) ^b	410	560	790	180	250	260	230	68	110	200	380	3,400
Cost of illness (M€, undiscounted) ^c	30	25	25	7	16	15	12	4	9	27	25	195
Cost of illness (M€, discounted (4%)) ^c	25	16	23	7	14	13	11	4	9	26	23	171

a) Due to the 14 pathogens included in this study

b) Presented numbers are rounded: $\geq 100,000$ 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 2013-2018, total and by pathogen

Pathogen	Incidence/year ^a					
	2013 ^b	2014 ^b	2015 ^b	2016	2017	2018
<i>Campylobacter</i> spp.	42,000	41,000	37,000	33,000	28,000	30,000
STEC O157	860	860	860	860	860	860
<i>Salmonella</i> spp.	15,000	15,000	15,000	18,000	15,000	14,000
<i>Listeria monocytogenes</i>	55	66	50	66	80	54
<i>B. cereus</i> toxine	46,000	46,000	46,000	47,000	47,000	47,000
<i>C. perfringens</i> toxine	153,000	154,000	154,000	154,000	155,000	155,000
<i>S. aureus</i> toxine	253,000	252,000	251,000	250,000	251,000	251,000
Norovirus	99,000	98,000	103,000	128,000	86,000	103,000
Rotavirus	39,000	16,000	34,000	18,000	27,000	29,000
Hepatitis-A virus	61	59	45	45	55	69
Hepatitis-E virus	74	180	260	260	180	180
<i>Cryptosporidium</i> spp.	6,200	6,200	11,000	13,000	8,200	10,900
<i>Giardia</i> spp.	11,000	11,000	11,000	11,000	11,000	11,000
<i>Toxoplasma gondii</i>	430	430	430	430	430	430
Total	665,000	640,000	663,000	673,000	629,000	652,000

- a) Presented numbers are rounded: $\geq 100,000$ 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, therefore estimates presented here for 2013-2015 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 2013-2018, total and by pathogen

Pathogen	Number of fatal cases /year					
	2013 ^a	2014 ^a	2015 ^a	2016	2017	2018
<i>Campylobacter</i> spp.	32	30	27	24	21	20
STEC O157	2	2	2	2	2	2
<i>Salmonella</i> spp.	16	15	15	18	19	14
<i>Listeria monocytogenes</i>	5	8	11	8	8	4
<i>B. cereus</i> toxine	0	0	0	0	0	0
<i>C. perfringens</i> toxine	4	4	4	4	4	4
<i>S. aureus</i> toxine	6	6	6	6	6	6
Norovirus	10	10	11	14	9	11
Rotavirus	6	3	6	3	5	5
Hepatitis-A virus	0	0	0	0	0	0
Hepatitis-E virus	1	2	3	3	2	2
<i>Cryptosporidium</i> spp.	0	0	1	1	1	1
<i>Giardia</i> spp.	0	0	0	0	0	0
<i>Toxoplasma gondii</i>	7	7	7	7	7	7
Total	90	88	93	90	83	76

a) Since the 2017-update new incidence estimates for hepatitis-E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2013-2015 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 2013-2018, total and by pathogen

Pathogen	DALY(undiscounted)/year ^a					
	2013 ^b	2014 ^b	2015 ^b	2016	2017	2018
<i>Campylobacter</i> spp.	1,900	1,900	1,700	1,500	1,300	1,300
STEC O157	61	61	61	61	61	61
<i>Salmonella</i> spp.	670	650	640	760	680	620
<i>Listeria monocytogenes</i>	68	190	170	310	190	180
<i>B. cereus</i> toxine	28	28	28	28	29	29
<i>C. perfringens</i> toxine	180	180	180	180	180	180
<i>S. aureus</i> toxine	190	190	190	190	190	190
Norovirus	290	280	300	380	270	320
Rotavirus	190	78	170	88	140	150
Hepatitis-A virus	7	6	5	5	6	8
Hepatitis-E virus	30	73	100	100	70	71
<i>Cryptosporidium</i> spp.	11	11	19	22	14	19
<i>Giardia</i> spp.	29	29	29	29	29	28
<i>Toxoplasma gondii</i>	1,100	1,100	1,100	1,100	1,100	1,100
Total	4,700	4,700	4,600	4,700	4,200	4,300

- a) Presented numbers are rounded: $\geq 100,000$ 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, therefore estimates presented here for 2013-2015 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 2018 euros) to food in the Netherlands for 2013-2018, total and by pathogen

Pathogen	COI per year (4%)/year ^a (Million €, expressed in 2018 euros)					
	2013 ^b	2014 ^b	2015 ^b	2016	2017	2018
<i>Campylobacter</i> spp.	33	33	30	27	23	25
STEC O157	2	2	2	2	2	2
<i>Salmonella</i> spp.	11	10	11	12	11	11
<i>Listeria monocytogenes</i>	2	2	2	2	2	2
<i>B. cereus</i> toxine	9	10	10	10	10	10
<i>C. perfringens</i> toxine	26	26	26	26	26	27
<i>S. aureus</i> toxine	53	53	52	52	52	53
Norovirus	17	17	18	22	15	18
Rotavirus	11	5	9	6	8	9
Hepatitis-A virus	0.1	0.09	0.07	0.07	0.3	0,11
Hepatitis-E virus	0.3	0.8	1	1	0.8	0,8
<i>Cryptosporidium</i> spp.	2	2	3	3	2	3
<i>Giardia</i> spp.	2	2	2	2	2	2
<i>Toxoplasma gondii</i>	9	9	8	8	8	9
Total	177	171	174	173	163	171

- 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, therefore estimates presented here for 2013-2015 are different from the one presented in earlier publications (i.e. [3-6]).

3 Discussion

We observed an overall increase in the number of incident cases of the 14 enteric food-related pathogens, especially for norovirus, *Cryptosporidium* spp. and rotavirus. However, the overall disease burden in 2018 was similar to 2017 (11,000 DALYs). This is because the aforementioned pathogens had a relatively low disease burden per case compared with other pathogens that have decreased. The disease burden is still lower than in 2012-2016 (range: 12,000 to 14,000 DALYs). Overall, the proportion of foodborne transmission was about 40%, and at 4,300 DALYs the attributable burden remained similar to 2017 (4,200 DALYs). Both the overall COI and the foodborne-related COI slightly increased in 2018 compared to 2017, but was within the range of 2013-2016. The slight increase of DALYs and COI falls within the range of natural fluctuations observed in disease incidence. A limitation is that for some of the pathogens, a stable incidence has been assumed due to lack of surveillance data, which may not accurately reflect the current incidence. Therefore, we aim to update the trend information for some of these pathogens in the coming year. Moreover, based on our surveillance data, we estimated the number of incident cases in the general population and visiting the GP using multiplication factors mostly from studies conducted in the late 90s. However, as these might not reflect the current situation they require an update. Lastly, some of the disease models will be updated using novel insights from literature, such as source attribution models on the fraction of human *Campylobacter* and *Salmonella* cases that is attributed to the five different major pathways (i.e. food, environment, etc.).

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5 Annex: Detailed results

Table A.1 – Mean number of incident cases by pathogen in the Netherlands, 2013-2018

Pathogen	Estimated mean number of incident cases/year ^a					
	2013 ^b	2014 ^b	2015 ^b	2016	2017	2018
<i>Campylobacter</i> spp.	100,000	98,000	89,000	79,000	67,000	71,000
STEC O157	2,100	2,100	2,100	2,100	2,100	2,100
<i>Salmonella</i> spp.	28,000	28,000	27,00	32,000	27,000	27,000
<i>Listeria monocytogenes</i>	79	96	72	96	115	78
<i>B. cereus</i> toxine	51,000	52,000	52,000	52,000	53,000	53,000
<i>C. perfringens</i> toxine	170,000	170,000	170,000	171,000	171,000	171,000
<i>S. aureus</i> toxine	290,000	288,000	288,000	287,000	287,000	288,000
Norovirus	592,000	585,000	615,000	765,000	515,000	615,000
Rotavirus	297,000	124,000	261,000	138,000	209,000	224,000
Hepatitis-A virus	530	510	390	400	1,800	900
Hepatitis-E virus	540	1,300	1,900	1,900	1,300	1,300
<i>Cryptosporidium</i> spp.	52,000	52,000	92,000	109,000	69,000	91,000
<i>Giardia</i> spp.	85,000	84,000	84,000	83,000	83,000	82,000
<i>Toxoplasma gondii</i>	770	780	770	770	770	770
Total	1,670,000	1,490,000	1,680,000	1,720,000	1,490,000	1,630,000

- a) Presented numbers are rounded: $\geq 100,000$ 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, therefore estimates presented here for 2013-2015 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, 2013-2018

Pathogen	Estimated mean number of fatal cases/year ^a					
	2013 ^b	2014 ^b	2015 ^b	2016	2017	2018
<i>Campylobacter</i> spp.	77	72	65	57	49	47
STEC O157	4	4	4	4	4	4
<i>Salmonella</i> spp.	30	28	28	32	34	25
<i>Listeria monocytogenes</i>	7	11	16	12	12	6
<i>B. cereus</i> toxine	0	0	0	0	0	0
<i>C. perfringens</i> toxine	5	5	5	5	5	5
<i>S. aureus</i> toxine	7	7	7	7	7	7
Norovirus	59	60	65	82	56	69
Rotavirus	47	20	43	23	35	38
Hepatitis-A virus	2	2	1	1	6	3
Hepatitis-E virus	6	15	22	21	15	15
<i>Cryptosporidium</i> spp.	3	3	6	7	4	6
<i>Giardia</i> spp.	2	2	2	2	2	2
<i>Toxoplasma gondii</i>	12	12	12	12	12	12
Total	260	240	280	270	240	238

- 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, therefore estimates presented here for 2013-2015 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 2013- 2018, total and by pathogen

Pathogen	DALY(undiscounted)/year ^a					
	2013 ^b	2014 ^b	2015 ^b	2016	2017	2018
<i>Campylobacter</i> spp.	4,600	4,500	4,000	3,600	3,100	3,200
STEC O157	150	150	150	150	150	150
<i>Salmonella</i> spp.	1,200	1,200	1,200	1,400	1,200	1,100
<i>Listeria monocytogenes</i>	98	280	240	450	280	260
<i>B. cereus</i> toxine	31	31	32	32	32	32
<i>C. perfringens</i> toxine	200	200	200	200	200	200
<i>S. aureus</i> toxine	220	220	220	220	220	220
Norovirus	1,700	1,700	1,800	2,200	1,600	1,900
Rotavirus	1,400	600	1,300	670	1,100	1,200
Hepatitis-A virus	59	57	43	44	200	100
Hepatitis-E virus	210	530	740	740	510	510
<i>Cryptosporidium</i> spp.	92	91	160	190	120	160
<i>Giardia</i> spp.	230	220	220	220	220	220
<i>Toxoplasma gondii</i>	1,900	2,000	1,900	1,900	1,900	1,900
Total	12,000	12,000	12,000	12,000	11,000	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, therefore estimates presented here for 2013-2015 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 2013-2018, total and by pathogen

Pathogen	COI per year (4%)/year ^a (Million €, expressed in 2017 euros)					
	2013 ^b	2014 ^b	2015 ^b	2016	2017	2018
<i>Campylobacter</i> spp.	80	79	72	65	56	60
STEC O157	6	6	6	6	6	6
<i>Salmonella</i> spp.	20	19	20	22	20	19
<i>Listeria monocytogenes</i>	3	3	3	3	3	3
<i>B. cereus</i> toxine	11	11	11	11	11	11
<i>C. perfringens</i> toxine	29	29	29	29	29	29
<i>S. aureus</i> toxine	62	61	61	61	61	61
Norovirus	105	103	109	134	92	109
Rotavirus	83	41	74	45	62	66
Hepatitis-A virus	0.9	0.8	0.6	0.6	3	1
Hepatitis-E virus	3	6	9	9	6	6
<i>Cryptosporidium</i> spp.	14	14	23	26	17	22
<i>Giardia</i> spp.	17	17	16	16	16	16
<i>Toxoplasma gondii</i>	16	16	15	15	15	15
Total	447	405	447	443	397	426

- 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, therefore estimates presented here for 2013-2015 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, 2018 ^a

Main pathway	Food	Environment	Human	Animal	Travel	Total
<i>Campylobacter</i> spp.	30,000	15,000	4,500	14,000	8,500	71,000
STEC O157	860	360	220	430	250	2,120
<i>Salmonella</i> spp.	14,000	3,400	2,500	2,400	3,700	27,000
<i>Listeria monocytogenes</i>	54	5	4	4	10	80
<i>B. cereus</i> toxine	47,000	580	640	580	3,900	53,000
<i>C. perfringens</i> toxine	155,000	3,800	3,600	3,600	5,500	171,000
<i>S. aureus</i> toxine	251,000	10,000	9,000	6,300	11,000	288,000
Norovirus	103,000	87,000	341,000	31,000	53,000	615,000
Rotavirus	29,000	38,000	130,000	6,700	20,000	224,000
Hepatitis-A virus	69	67	400	0	360	900
Hepatitis-E virus	180	320	98	140	550	1,300
<i>Cryptosporidium</i> spp.	10,900	25,000	25,000	12,200	18,000	91,000
<i>Giardia</i> spp.	11,000	20,000	29,000	8,800	15,000	82,000
<i>Toxoplasma gondii</i>	430	280	7	19	35	770
Total	652,000	204,000	546,000	86,000	140,000	1,630,000

a) Presented numbers are rounded: $\geq 100,000$ 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) underascertainment (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, 2018 ^a

Main pathway	Food	Environment	Human	Animal	Travel	Total
<i>Campylobacter</i> spp.	20	10	3	9	6	47
STEC O157	2	0.7	0.4	0.8	0.5	4
<i>Salmonella</i> spp.	14	3	2	2	4	25
<i>Listeria monocytogenes</i>	4	0.4	0.3	0.3	1	6
<i>B. cereus</i> toxine	0	0	0	0	0	0
<i>C. perfringens</i> toxine	4	0.1	0.1	0.1	0.1	5
<i>S. aureus</i> toxine	6	0.3	0.2	0.2	0.3	7
Norovirus	12	10	38	3	6	69
Rotavirus	5	7	22	1	3	38
Hepatitis-A virus	0.2	0.2	1	0	1.1	3
Hepatitis-E virus	2	4	1	2	6	15
<i>Cryptosporidium</i> spp.	0.7	2	2	0.7	1.1	6
<i>Giardia</i> spp.	0.3	0.5	0.8	0.2	0.4	2
<i>Toxoplasma gondii</i>	7	4	0.1	0.3	0.6	12
Total	76	41	71	20	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, 2018^a

Main pathway	Food	Environment	Human	Animal	Travel	Total
<i>Campylobacter</i> spp.	1.300	660	200	610	380	3.200
STEC O157	61	26	15	31	18	150
<i>Salmonella</i> spp.	620	150	110	100	160	1.100
<i>Listeria monocytogenes</i>	180	18	14	14	35	260
<i>B. cereus</i> toxine	29	0	0	0	2	32
<i>C. perfringens</i> toxine	180	4	4	4	6	200
<i>S. aureus</i> toxine	190	8	7	5	8	220
Norovirus	320	280	1.070	97	170	1.900
Rotavirus	150	200	690	35	105	1.200
Hepatitis-A virus	8	7	50	0	39	100
Hepatitis-E virus	71	130	39	56	220	510
<i>Cryptosporidium</i> spp.	19	43	43	21	31	160
<i>Giardia</i> spp.	28	52	76	23	39	220
<i>Toxoplasma gondii</i>	1.100	690	17	48	88	1.900
Total	4.300	2.300	2.300	1.100	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 2018 euros) to main pathways in the Netherlands, 2018

Main pathway	Food	Environment	Human	Animal	Travel	Total
<i>Campylobacter</i> spp.	25	12	4	11	7	60
STEC O157	2	1	0.6	1	0.7	6
<i>Salmonella</i> spp.	11	3	2	2	3	19
<i>Listeria monocytogenes</i>	2	0.2	0.2	0.2	0.4	3
<i>B. cereus</i> toxine	10	0.1	0.1	0.1	0.8	11
<i>C. perfringens</i> toxine	27	0.6	0.6	0.6	0.9	29
<i>S. aureus</i> toxine	53	2	2	1	2	61
Norovirus	18	16	60	6	10	109
Rotavirus	9	11	38	2	6	66
Hepatitis-A virus	0.1	0.1	1	0.0	0.6	2
Hepatitis-E virus	0.8	2	0.5	0.6	3	6
<i>Cryptosporidium</i> spp.	3	6	6	3	4	22
<i>Giardia</i> spp.	2	4	6	2	3	16
<i>Toxoplasma gondii</i>	9	6	0.1	0.4	0.7	15
Total	171	63	121	30	42	426

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, 2018^a

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
<i>Campylobacter</i> spp.	1,200	1,500	16,000	930	2,700	2,100	1,600	510	690	990	1,600	30,000
STEC O157	380	55	27	18	63	25	61	31	25	30	140	860
<i>Salmonella</i> spp.	1,800	2,100	2,100	3,200	950	590	910	450	620	870	820	14,000
<i>Listeria monocytogenes</i>	6	5	4	2	13	10	4	1	3	3	3	54
<i>B. cereus</i> toxine	3,400	1,700	760	1,700	2,700	950	950	800	8,000	25,000	1,100	47,000
<i>C. perfringens</i> toxine	74,000	13,000	11,000	4,300	6,300	10,000	11,000	3,900	4,000	12,000	5,600	155,000
<i>S. aureus</i> 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	3,300	3,200	3,000	2,000	2,100	16,000	7,500	3,200	5,300	5,100	52,000	103,000
Rotavirus	0	820	0	0	500	5,700	6,900	1,300	2,200	1,300	10,500	29,000
Hepatitis-A virus	0	0	0	0	0	9	9	3	3	2	43	69
Hepatitis-E virus	0	130	0	0	0	9	13	6	0	0	18	180
<i>Cryptosporidium</i> spp.	2,800	480	320	290	1,000	2,400	2,300	330	0	330	660	10,900
<i>Giardia</i> spp.	2,100	510	330	0	830	1,400	3,500	340	0	350	1,300	11,000
<i>Toxoplasma gondii</i>	98	220	21	0	20	16	25	0	0	10	25	430
Total	108,000	44,000	53,000	21,000	54,000	54,000	39,000	15,000	40,000	120,000	104,000	652,000

a) Presented numbers are rounded: $\geq 100,000$ 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, 2018^a

Food groups	Beef & lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
<i>Campylobacter</i> spp.	0.8	1	11	0.6	2	1	1	0.3	0.5	0.6	1	20
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
<i>Salmonella</i> spp.	2	2	2	3	1	0.6	1	0.4	0.6	1	1	14
<i>Listeria</i> <i>monocytogenes</i>	0.5	0.4	0.3	0.2	1	1	0.3	0.1	0.2	0.2	0.2	4
<i>B. cereus</i> 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
<i>C. perfringens</i> toxine	2	0.4	0.3	0.1	0.2	0.3	0.3	0.1	0.1	0.3	0.2	4
<i>S. aureus</i> toxine	0.5	0.5	0.5	0.2	0.9	0.4	0.1	0.1	0.5	2	0.7	6
Norovirus	0.4	0.4	0.3	0.2	0.2	2	0.8	0.4	0.6	0.6	6	11
Rotavirus	0.0	0.1	0.0	0.0	0.1	1.0	1	0.2	0.4	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
<i>Cryptosporidium</i> spp.	0.2	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	1
<i>Giardia</i> 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
<i>Toxoplasma gondii</i>	2	3	0.3	0.0	0.3	0.2	0.4	0.0	0.0	0.2	0.4	7
Total	8	10	14	4	6	7	6	2	3	5	12	76

- 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, 2018^a

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish & shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
<i>Campylobacter</i> spp.	55	69	720	42	120	94	71	23	31	44	71	1,300
STEC O157	27	4	2	1	5	2	4	2	2	2	10	61
<i>Salmonella</i> spp.	78	88	90	140	41	25	39	19	27	37	35	620
<i>Listeria monocytogenes</i>	20	17	12	7	45	32	14	5	11	10	9	180
<i>B. cereus</i> toxine	2	1	0.5	1	2	0.6	0.6	0.5	5	15	0.7	29
<i>C. perfringens</i> toxine	85	15	13	5	7	12	12	4	5	14	6	180
<i>S. aureus</i> toxine	14	16	15	6	28	11	4	3	14	57	23	190
Norovirus	10	10	9	6	6	50	24	10	17	16	160	320
Rotavirus	0	4	0	0	3	30	37	7	12	7	55	150
Hepatitis-A virus	0	0	0	0	0	1.0	1.0	0.3	0.3	0.2	5	8
Hepatitis-E virus	0	52	0	0	0	3	5	2	0	0	7	71
<i>Cryptosporidium</i> spp.	5	0.8	0.5	0.5	2	4	4	0.6	0	0.6	1	19
<i>Giardia</i> spp.	6	1	0.9	0	2	4	9	0.9	0	0.9	3	28
<i>Toxoplasma gondii</i>	240	530	51	0	49	39	62	0	0	24	61	1,100
Total	550	810	920	210	310	310	290	78	120	230	450	4,300

- 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 2018 euros) by pathogen to food groups in the Netherlands, 2018^a

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish& shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
<i>Campylobacter</i> spp.	1.0	1	14	0.8	2	2	1	0.4	0.6	0.8	1	25
STEC O157	1.0	0.2	0.07	0.05	0.2	0.07	0.2	0.08	0.07	0.08	0.4	2
<i>Salmonella</i> spp.	1	2	2	2	0.7	0.4	0.7	0.3	0.5	0.6	0.6	11
<i>Listeria monocytogenes</i>	0.3	0.2	0.2	0.09	0.6	0.4	0.2	0.06	0.1	0.1	0.1	2
<i>B. cereus</i> toxine	0.7	0.3	0.2	0.4	0.6	0.2	0.2	0.2	2	5	0.2	10
<i>C. perfringens</i> toxine	13	2	2	0.7	1	2	2	0.7	0.7	2	1.0	27
<i>S. aureus</i> toxine	4	4	4	2	8	3	1	1.0	4	16	6	53
Norovirus	0.6	0.6	0.5	0.3	0.4	3	1	0.6	0.9	0.9	9	18
Rotavirus	0	0.2	0	0	0	2	2	0.4	0.6	0.4	3	9
Hepatitis-A virus	0	0	0	0	0	0.01	0.01	0.005	0.005	0.003	0.07	0.11
Hepatitis-E virus	0	0.6	0	0	0	0.04	0.06	0.03	0	0	0.08	0.8
<i>Cryptosporidium</i> spp.	0.7	0.1	0.1	0.1	0.2	0.6	0.5	0.1	0	0.1	0.16	3
<i>Giardia</i> spp.	0.4	0.1	0.1	0	0.2	0.3	0.7	0.1	0	0.1	0.3	2
<i>Toxoplasma gondii</i>	2	4.3	0.4	0.0	0.4	0.3	0.5	0.0	0	0.2	0.5	9
Total	25	16	23	7	15	13	11	4	9	26	23	171

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)

