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

Disease burden of food-related pathogens in the Netherlands, 2019

This report contains an erratum d.d. 21-01-2021 on page 51

RIVM letter report 2020-0117
G.R. Lagerweij et al.

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

Disease burden of food-related pathogens in the Netherlands, 2019

This report contains an erratum d.d. 21-01-2021 on page 51

RIVM letter report 2020-0117
G.R. Lagerweij et al.

Colophon

DOI 10.21945/RIVM-2020-0117

G.R. Lagerweij (author), RIVM
R. Pijnacker (author), RIVM
I.H.M. Friesema (author), RIVM
L. Mughini Gras (author), RIVM
E. Franz (author), RIVM

Contact:
Giske Lagerweij
Centre for Infectious Disease Control
giske.lagerweij@rivm.nl

This investigation has been performed by order and for the account of Ministerie van VWS, within the framework of Programma 5

Published by:
National Institute for Public Health and the Environment, RIVM
P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

Synopsis

The burden of disease from foodborne pathogens in the Netherlands in 2019

Every year, RIVM investigates how many people become sick or die from 14 pathogens that can infect the stomach or intestines. This is termed the 'burden of disease' and it is expressed in DALYs (Disability Adjusted Life Years), an international measure for the number of healthy years of life that are lost to disease or because of people dying earlier than 'normal'.

Not only can the 14 pathogens in question enter the human body via food (approximately 40% of infections), but also via the environment (for example, via surface water), animals and other people. The percentages of routes by which humans become infected vary depending on the pathogen concerned. The total number of DALYs these 14 pathogens caused in 2019 was the same as in 2018 and 2017 (11,000 DALYs). The burden of disease via food in 2019 was estimated at 4,200 and was slightly lower than in 2018 (4,300 DALYs).

The total cost of this burden of disease was estimated at EUR 423 million, which is lower than in 2018 (EUR 426 million). This *cost of illness* comprises direct medical costs and costs for patients and/or their families, including travel expenses, and costs for other sectors, such as those due to absenteeism.

The cost of the burden of disease caused by infected food has risen slightly: EUR 174 million in 2019 compared to EUR 171 million in 2018. The difference in DALYs and costs are mainly due to the fact that the number of infections caused by some of the pathogens has changed. This is particularly the case with norovirus, rotavirus, *and Cryptosporidium and Campylobacter* spp.

RIVM was commissioned to carry out this study by the Ministry of Health, Welfare and Sport (VWS). The results will help to provide a better understanding of the burden of disease and exposure routes of foodborne infections among the Dutch population. They also show the developments over the years.

Keywords: food-related disease, burden of disease, DALY, costs.

Publiekssamenvatting

Ziektelast van voedseloverdraagbare ziekteverwekkers in Nederland in 2019

Het RIVM onderzoekt elk jaar hoeveel mensen ziek worden of sterven door 14 ziekteverwekkers die de maag of darm kunnen infecteren. Deze zogeheten ziektelast wordt uitgedrukt in DALY's (Disability Adjusted Life Year), een internationale maat voor het aantal gezonde levensjaren dat verloren gaat aan ziekte of eerder dan 'normaal' overlijden.

De 14 ziekteverwekkers kunnen niet alleen via voedsel in het lichaam van de mens terechtkomen (ongeveer 40 procent). Het kan ook via het milieu (bijvoorbeeld via oppervlaktewater), dieren, en van mens op mens. Het aandeel van deze routes verschilt per ziekteverwekker. Het totaal aantal DALY's die deze 14 ziekteverwekkers in 2019 veroorzaakten, is hetzelfde als in 2018 en 2017 (11.000 DALY's). De ziektelast via voedsel is in 2019 geschat op 4.200, en is daarmee iets lager dan in 2018 (4.300 DALY's).

De totale kosten van deze ziektelast worden geschat op 423 miljoen euro. Dat is lager dan in 2018 (426 miljoen). Deze *cost of illness* zijn directe medische kosten, maar ook de kosten voor de patiënt en/of zijn familie. Dat zijn bijvoorbeeld reiskosten, en de kosten binnen andere sectoren, zoals door werkverzuim.

De kosten van de ziektelast door besmet voedsel zijn iets gestegen: 174 miljoen euro in 2019 ten opzichte van 171 miljoen euro in 2018. De verschillen in DALY's en kosten komen vooral doordat het aantal infecties dat een aantal van de ziekteverwekkers veroorzaakte veranderde. Het gaat om norovirus, rotavirus, *Cryptosporidium spp., en Campylobacter* spp.

Het RIVM heeft dit onderzoek in opdracht van het ministerie van VWS uitgevoerd. De resultaten geven handvatten om meer zicht te krijgen op de ziektelast en blootstellingsroutes van voedselinfecties bij de Nederlandse bevolking. Ook laten ze de ontwikkelingen hierin door de jaren heen zien.

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

Contents

Introduction — 9

1 Methods — 11
1.1 Trend information — 11
1.2 Burden of disease — 12
1.3 Cost of illness — 12
1.4 Attribution — 12

2 Results — 15
2.1 Trend information — 15
2.2 Number of incident cases — 18
2.3 Disease burden by pathogen — 21
2.4 Cost-of-illness by pathogen — 24
2.5 Attribution — 27

3 Discussion — 33

4 References — 35

5 Annex: Detailed results — 37

Erratum — 51

Introduction

Foodborne diseases encompass acute and chronic syndromes with varying duration and severity, as well as mortality. Risk-based food safety management (i.e. decisions on control, prevention and surveillance) requires a consistent, quantitative assessment of the relative public health importance of foodborne diseases [1]. As such, we express the public health impact of foodborne pathogens in burden of disease (BoD) and cost-of-illness (COI). The methodology that is used to estimate the burden of disease (in terms of Disability Adjusted Life Years (DALY)) is described in detail in a peer-reviewed paper [1], and in the disease burden report of food-related pathogens over the year 2015 [2].

Since 2008, the RIVM regularly publishes estimates of the number of incident cases, burden of disease, and costs of food-related infectious disease on its webpages[1], and since 2010 in publicly available reports (e.g. [3, 4]). 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 2019. For 2019 (and onwards), we did not estimate the burden of disease and costs for toxin-producing bacteria *Bacillus cereus*, *Clostridium perfringens* and *Staphylococcus aureus*, due to the absence of surveillance on these infections. However, for the overall 2019 estimates, these three pathogens were included in the tables and figures (based on data from previous years [4]) to have no breach in trend over time regarding the total burden and costs.

[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 (Table 1), as well as mortality risks and the number of live births and stillbirths (Table 2) were obtained from Statistics Netherlands[2].

Table 1 Population in the Netherlands by age group, 2015-2019

Age group	2019	2018	2017	2016	2015
0	168,443	169,566	172,288	170,341	174,681
1-4	697,619	698,533	700,001	706,513	713,641
5-11	1,294,145	1,303,023	1,307,281	1,313,978	1,324,894
12-17	1,197,548	1,214,974	1,224,528	1,225,749	1,215,977
18-64	10,610,404	10,555,872	10,517,749	10,477,231	10,463,848
65+	3,314,004	3,239,116	3,159,660	3,085,308	3,007,685
Total	17,282,163	17,181,084	17,081,507	16,979,120	16,900,726

Table 2 Live births by age of mothers in the Netherlands, 2015-2019

Age of mother	2019*	2018	2017	2016	2015
-19	890	950	1,023	1,076	1,109
20-24	10,485	11,223	11,722	12,580	13,125
25-29	44,660	45,974	47,197	48,557	48,724
30-34	68,165	68,110	67,575	67,760	66,373
35-39	34,452	34,715	34,905	35,205	34,070
40-44	7,151	7,089	6,941	6,922	6,733
45+	496	464	473	420	376
Total	166,299	168,525	169,836	172,520	170,510

* Estimates based on observed trend from 2016-2018

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 ISIS-AMR laboratory surveillance;
- Non-typhoidal *Salmonella* spp.: RIVM passive 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 [5] and is therefore different with earlier publications [2] where a stable incidence based on Borgen et al. was assumed [6].

[2] Birth; key figures; accessed February 3th 2020

- *Cryptosporidium* spp.: RIVM laboratory surveillance data since 2013 until 2018, for 2019 the incidence is estimated based on observed trend from 2016-2018. Note that the incidence was adapted in 2017 [5] and is therefore different with earlier publications [2] 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 [5] and is therefore different with earlier publications [2, 5] 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 Burden of disease

The method for the burden of disease calculations, in terms of Disability Adjusted Life Years (DALYs), was not changed since 2018 (i.e. reporting over 2017) [3].

1.3 Cost of illness

The method for COI estimates was not changed since the previous 2018 report [3]. The cost prices used for the different resources was updated to 2019 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., 2015-2018) to 2019 euros; hence all differences in the results for the year 2019 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

[3] Consumer prices; accessed at February 3th, 2020

(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. [7]. The method and estimates for attribution were not changed since then.

2 Results

2.1 Trend information

Trend information for the last five years for specific pathogens is presented in Table 3. For trend information since 1999 for the 14 pathogens, see Annex - Table A.1.
A summary of trends (in comparison with 2018) is discussed below:

- The incidence of campylobacteriosis (laboratory confirmed cases) stayed similar compared with 2018, i.e. 35 cases per 100,000 inhabitants in 2019.
- The incidence of salmonellosis (laboratory confirmed cases) is with 9 cases per 100,000 inhabitants similar to 2015-2018 (range: 9 to 11 per 100,000 inhabitants).
- Because the incidence of cryptosporidiosis (laboratory confirmed cases) was based on data from 2016-2018, no trend information was available.
- The incidence of gastroenteritis due to rotavirus (laboratory confirmed cases) in 2019 (16 per 100,000 inhabitants) was similar to 2018 (17 per 100,000 inhabitants). The observed biannual trend of a low epidemic year followed by a high epidemic year that was observed in 2014-2017 did not continue.
- The incidence of gastroenteritis by norovirus (laboratory confirmed cases) was with 25 cases per 100,000 inhabitants slighter lower than in 2018 (27 per 100,000 inhabitants).
- The incidence of acquired listeriosis (laboratory confirmed cases, active surveillance) increased from 71 cases in 2018 to 113 cases in 2019. The recorded fatalities increased from 4 cases (2018) to 16 cases in 2019. In the last 10 years, it occurred once that the recorded fatalities were higher than 10 (i.e. 15 cases in 2015).
- In 2019 the incidence of perinatal listeriosis (laboratory confirmed cases, active surveillance) was 4 cases with 0 fatalities. This was lower than in 2018, with 7 cases and 2 fatalities.
- The incidence of diseases caused by STEC O157 (laboratory confirmed cases, active surveillance) in 2019 was 35 laboratory confirmed cases of which 13 were hospitalized, which is the lowest incidence within the last 10 years. The number of patients with HUS was with 2 cases in 2019 lower than in 2018 (5 cases) and comparable with 2014-2017 with 2 or 3 cases annually.
- The incidence of hepatitis A virus (notified cases, active surveillance) was 166 reported cases and 135 hospitalized cases far higher than in earlier years (~ 80 cases in 2016 and 2015), but lower than in 2017 and 2018 (i.e. 374 and 188 cases). The high number of cases in 2017 was due to an international outbreak in men having sex with men, which peaked in 2017 and decreased throughout 2018 and 2019.
- 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 and 2018 (2 cases per 100,000 inhabitants).

- The number of patients that were admitted to the hospital due to GE was estimated to be 21.599 in 2019, compared with 21.845 in 2018.

Table 3 Trends in incidence per 100,000 inhabitants and reported cases, respectively, of food-related pathogens, 2015-2019

		Year				
		2015	**2016**	**2017**	**2018**	**2019**
Campylobacter spp. [a]		*43*	*38*	*33*	*35*	*35*
Salmonella spp. [a]		*9*	*11*	*9*	*9*	*9*
Cryptosporidium spp. [a]		*10*	*12*	*8*	*10*	*8*
Rotavirus [a]		*20*	*10*	*16*	*17*	*16*
Norovirus [a]		*27*[c]	*33*[c]	*23*[c]	*27*[c]	*25*[c]
Acquired listeriosis [b]		69	89	112	71	113
	Fatal	15	8	10	4	16
Perinatal listeriosis [b]		3	7	3	7	4
	Fatal	1	4	2	2	0
STEC O157 [b]		76	64	58	59	35
	Hospitalized	27[h]	21[i]	23	23[j]	13
Hepatitis A virus [b]		80	81	374[k]	188[l]	166
	Hospitalized	23	22	90[m]	57[n]	135[o]
Hepatitis E virus [a]		*3*	*3*	*2*	*2*	*2*

Notes: a) Incidences per 100,000 habitants are presented in italics and the 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; o) known for 159/166 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 2019 is presented in Table 4. The estimated number of incident cases of diseases by non-gastrointestinal pathogens in 2019 is presented in Table 5. The number of incident cases by the 14 pathogens for the years 2015-2019 is presented in Figure 1 and in Table A.2 in Annex I.

There was a small decrease of the estimated total number of cases due to the 14 food-related pathogens from 1,630,000 in 2018 to 1,570,000 in 2019, a result mostly due to the lower number of incident cases of norovirus, rotavirus, and *Cryptosporidium spp.*. The estimated incidence of the remaining pathogens did hardly change, mostly because of the following two reasons:

a) estimates were based on surveillance data from previous years because no data was available for these pathogens for 2019 (i.e. three toxin producing bacteria and *Giardia*)
b) estimates who were based on (active/passive) laboratory surveillances for 2019 hardly differed from the data of 2018 (i.e. the other pathogens; *Campylobacter* spp., *Salmonella* spp., STEC, *Listeria*, and hepatitis-A and -E).

Table 4 Mean estimated number of incident cases and 95% uncertainty interval (between brackets) of gastroenteritis by pathogen in the Netherlands, 2019

Pathogen	**Number of incident cases#**			**Fatal cases#**
	General population (x 1,000)	**GP visit (x 1,000)**	**Hospitalised (x 1,000)**	
All causes	4,860 (4040-5780)	223 (1-225)	22 -	NA#
Bacteria – infectious	73.0 (9.5-198)	18 (8.6-33)	1.1 (0.4-2.1)	53 (35-73)
Campylobacter spp.	2.1 (0.2-8.8)	0 (0-0)	0.0 (0.02-0.02)	4 (2-7)
STEC O157	26.0 (2.4-81)	4 (2-6.5)	1.1 (0.1-0.5)	24 (0-0)
Salmonella spp.				
Bacteria – toxin producing				
Bacillus cereus	53.0 (18-127)	8 (1.7-20)	0.2 (-)	0 (2-4)
Clostridium perfringens	173.0 (57.3-384)	32 (7.7-84)	0.3 (1-3.2)	5 (27-125)
Staphylococcus aureus	289.0 (124-554)	40 (12-95)	1.5 (0.2-1.2)	7 (0-20)
Viruses	585.0 (393-851)	13 (7.6-22)	1.9 (1-3.2)	66 (27-125)
Norovirus	211.0 (104-382)	12 (7.8-19)	5.5 (4.1-7.4)	36 (11-81)
Rotavirus				
Protozoa	72.0 (22-179)	4 (2.1-7.7)	0.6 (0.2-1.2)	4 (0-20)
Cryptosporidium spp.	83.0 (41-163)	8 (3.9-13)	0.4 (0.04-1.4)	2 (0-9)
Giardia spp.	53.0 (18-127)	8 (1.7-20)	0.2 (-)	0 (2-4)

#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 5 Mean estimated number of incident cases and 95% uncertainty interval (between brackets) of non-gastrointestinal pathogen in the Netherlands, 2019

Pathogen	**Number of incident cases** ***mean (95% CI)***		**Fatal cases** ***mean (95% CI)***	
Listeria monocytogenes				
Perinatal	4	*	16	*
Acquired	113	*	0	*
Hepatitis A virus[#]	700	(500-1300)	3	(2-4)
Hepatitis E virus[#]	1,200	(680-1800)	13	(4-29)
Toxoplasma gondii[#]				
Congenital	334	(174-587)	12	(8-19)
Acquired**	430	(201-729)	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).

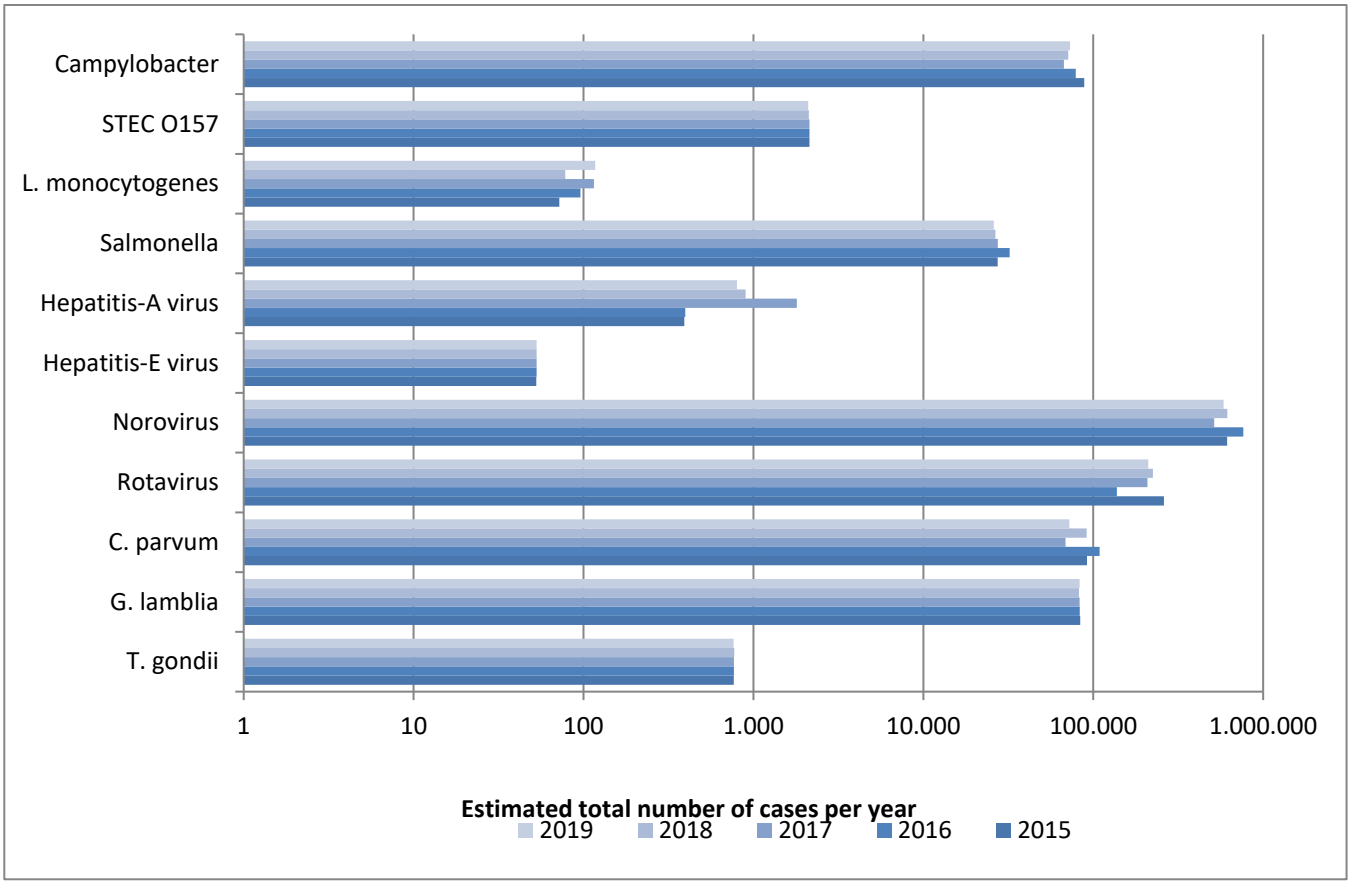

Figure 1 Comparison of mean estimated number of incident cases of food-related pathogens, 2015-2019

* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

The total number of estimated deaths due to foodborne disease in 2019 was slightly higher than in 2018, with 245 deaths compared to 238 (see Table A.3 in Annex).

2.3 Disease burden by pathogen

Table 6 presents the estimated burden of disease by pathogen for the total Dutch population in 2019, expressed as DALY per 100,000 inhabitants and DALY per case, both undiscounted and discounted.

The total burden of disease of the 14 pathogens in 2019 was similar to 2018 and 2017, with 11,000 DALYs, but lower than 2015-2016 (Table A.4 in Annex). An increase in the burden of disease between 2018 and 2019 was found for *Campylobacter* spp. (+100 DALYs). For norovirus and rotavirus, the largest decrease in disease burden was found, i.e. -100 DALYs. The largest burden at population level was caused by *Campylobacter* spp. (3,300 DALY), followed by *T. gondii* (1,900 DALYs) and norovirus (1,800 DALYs). Regarding zoonotic foodborne pathogens, *Salmonella* ranked second after *Campylobacter* spp. with 1,100 DALYs. Interestingly, although the disease burden for *Campylobacter* spp. has continually decreased since 2010, the disease burden slightly increased in 2018 and this increase continued in 2019. Perinatal listeriosis was the disease outcome with the highest individual burden among all pathogens (10 DALY per case), followed by congenital toxoplasmosis (5 DALY per case).

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 40% and YLL 46% of the total disease burden. The distribution between the different categories varied between pathogens, see Figure 2 for details.

Table 6 Mean total DALY per year, DALY per 100,000 inhabitants and DALY per case of illness in the Netherlands, 2019[#]

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.	3,300	2,900	19	17	0.05	0.04
STEC O157	150	120	0.9	0.7	0.07	0.05
Salmonella spp.	1,100	1,000	6.4	5.6	0.04	0.04
L. monocytogenes (perinatal)	40	20	0.2	0.1	10	6
L. monocytogenes (acquired)	142	134	0.8	0.8	1.3	1.2
L. monocytogenes (total)	180	160	1.1	0.9	1.6	1.3
Bacteria – toxin producing						
Bacillus cereus	32	32	0	0	0.001	0.001
Clostridium perfringens	200	193	1	1	0.001	0.001
Staphylococcus aureus	220	210	1	1	0.001	0.001
Viruses						
Norovirus	1,800	1,700	10.6	9.6	0.003	0.003
Rotavirus	1,100	990	6.5	5.7	0.005	0.005
Hepatitis A virus	90	70	0.5	0.4	0.11	0.09
Hepatitis E virus	460	360	2.6	2.1	0.4	0.3
Protozoa						
Cryptosporidium spp.	120	120	0.7	0.7	0.002	0.002
Giardia spp.	220	220	1.3	1.3	0.003	0.003
Toxoplasma gondii (congenital)	1,600	960	9.2	5.5	5	3
Toxoplasma gondii (acquired)	290	1,090	1.6	6.3	0.7	2.5
Toxoplasma gondii (total)	1,900	1,100	11	6.4	2.4	1
TOTAL	**11.000**	**9.000**	**64**	**52**		

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).

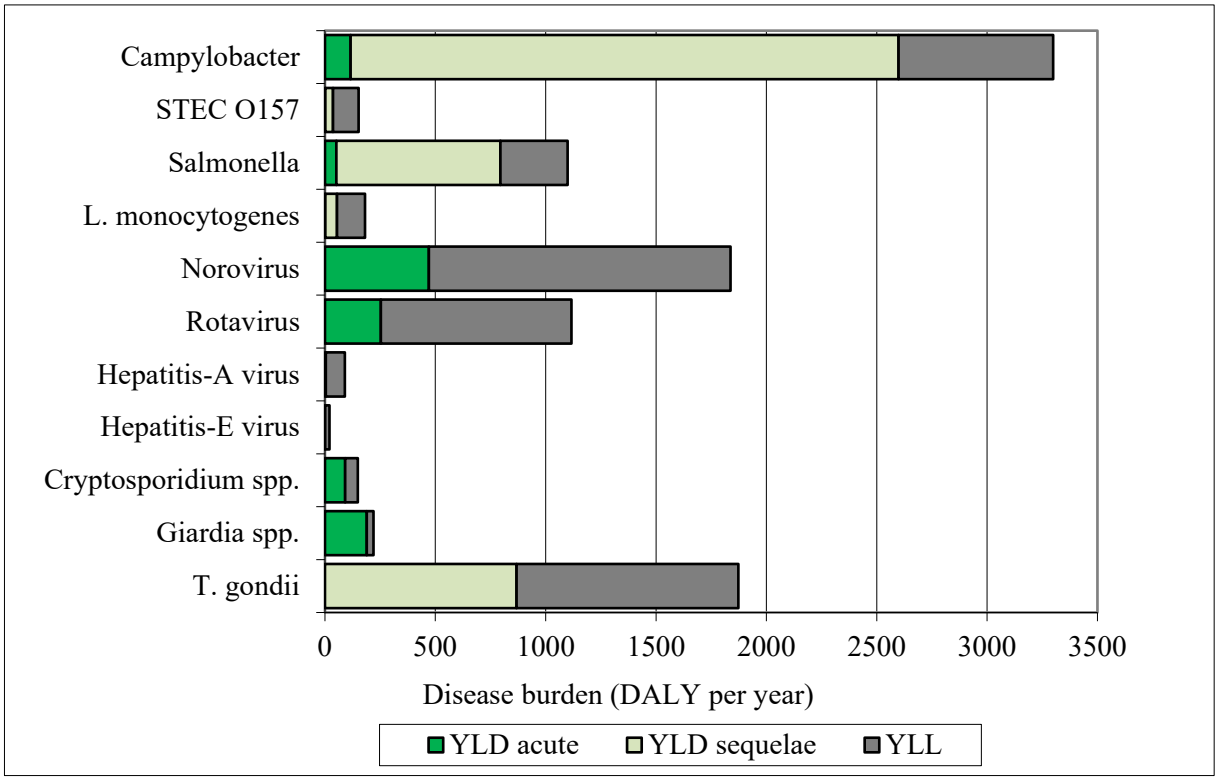

Figure 2 Mean DALY per year of food-related pathogens in 2019, split up into YLD associated with acute infections; YLD associated with sequelae and YLL.

The mean disease burden by the 14 pathogens for the years 2015-2019 is presented in Figure 3 and in Table A.4 in Annex.

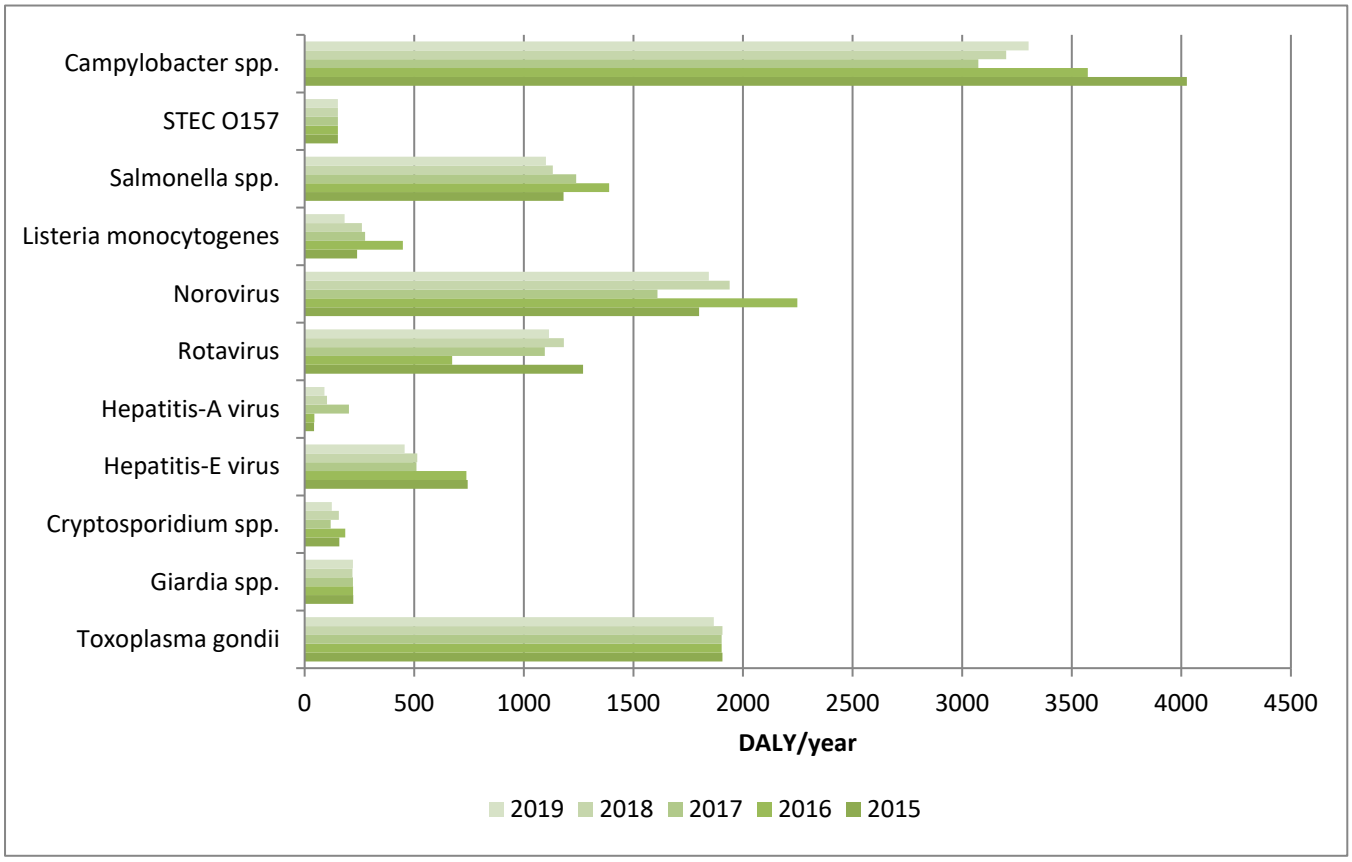

Figure 3 Comparison of disease burden (undiscounted DALYs) of food-related pathogens in 2015-2019
* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

2.4 Cost-of-illness by pathogen

The total COI in 2019 (423 M€; discounted at 4%) was slightly lower than in 2018 (426 M€) (Table 7, Figures 4-5, and Annex Table A.5). The four pathogens causing the largest COI were norovirus (106 M€), rotavirus (64 M€), *Staphylococcus aureus* toxin (63 M€), and *Campylobacter* (62 M€). The lowest contribution to the COI was by hepatitis A virus (1.3 M€). The largest changes in COI compared to 2018 were for *Cryptosporidium* (- 3.6 M€) and norovirus (-3.2 M€). The average cost per case was largest for perinatal *Listeria monocytogenes* infections (€291,000/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, 2019

Pathogen	**COI/year (M€)***		**COI per 100,000 (k€)***		**COI per case (€)***	
Discount rate	**0%**	**4%**	**0%**	**4%**	**0%**	**4%**
Bacteria – infectious						
Campylobacter spp.	67	62	388	358	920	850
STEC O157	11	5.7	65	33	5,400	2,700
Salmonella spp.	21	19	120	112	800	750
L. monocytogenes (perinatal)	3.4	1.2	19.6	6.7	849,000	291,000
L. monocytogenes (acquired)	3.3	3.1	19	18	29,000	27,000
L. monocytogenes (total)	6.7	4.3	39	25	57,000	36,000
Bacteria – toxin producing						
Bacillus cereus	12	12	67	67	220	220
Clostridium perfringens	30	30	172	172	170	170
Staphylococcus aureus	63	63	363	363	220	220
Viruses						
Norovirus	106	106	612	612	180	180
Rotavirus	64	64	370	370	300	300
Hepatitis A virus	1.3	1.3	8	8	2,000	2,000
Hepatitis E virus	5.5	4.7	32	32	4,800	4,800
Protozoa						
Cryptosporidium spp.	19	19	108	108	260	260
Giardia spp.	17	17	97	97	200	200
Toxoplasma gondii (congenital)	44	14	256	82	767,000	42,000
Toxoplasma gondii (acquired)	1.2	1.2	7.0	7.0	16,300	2,800
Toxoplasma gondii (total)	45	15	263	89	59,000	20,000
TOTAL	**467**	**423**	**2700**	**2450**		

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: ≥ 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 latter was 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.

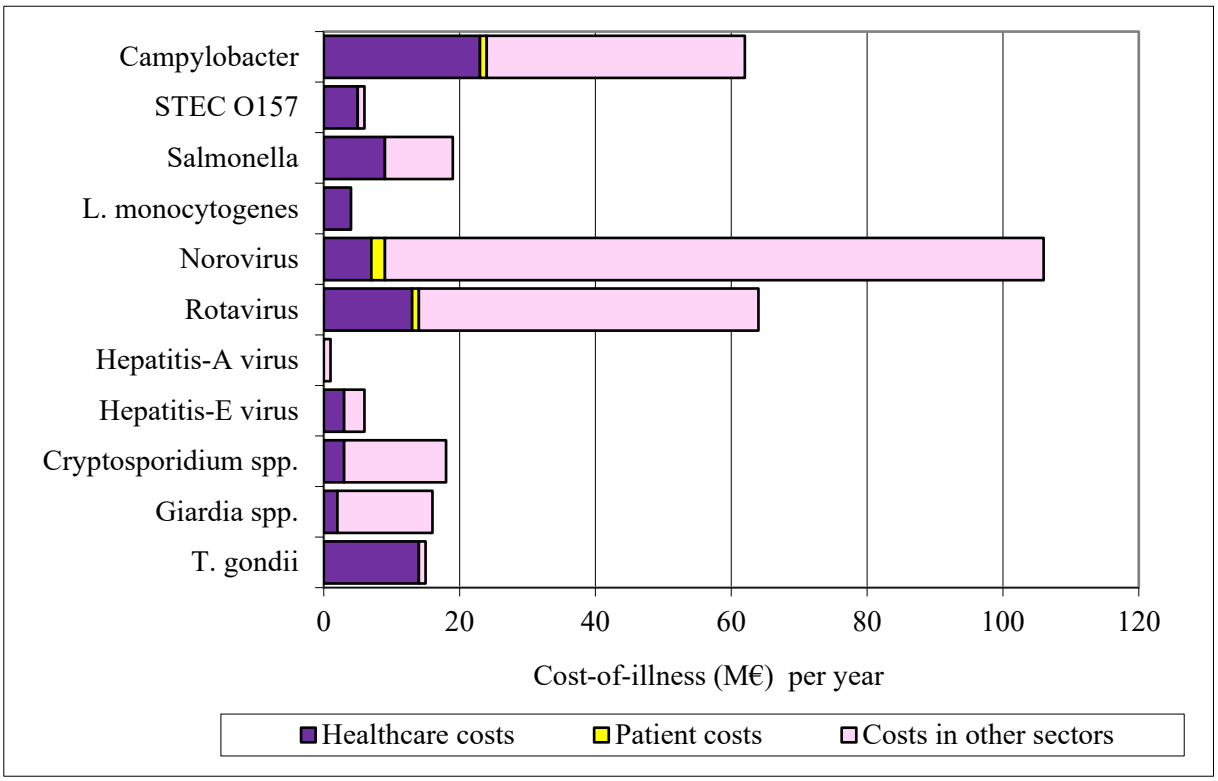

Figure 4 Mean cost-of-illness (discounted) per year of food-related pathogens in 2019, split up into healthcare costs, patient costs and costs in other sectors.

The mean COI estimates per pathogen for the years 2015-2019 is presented in Figure 5 and in Table A.4 in Annex.

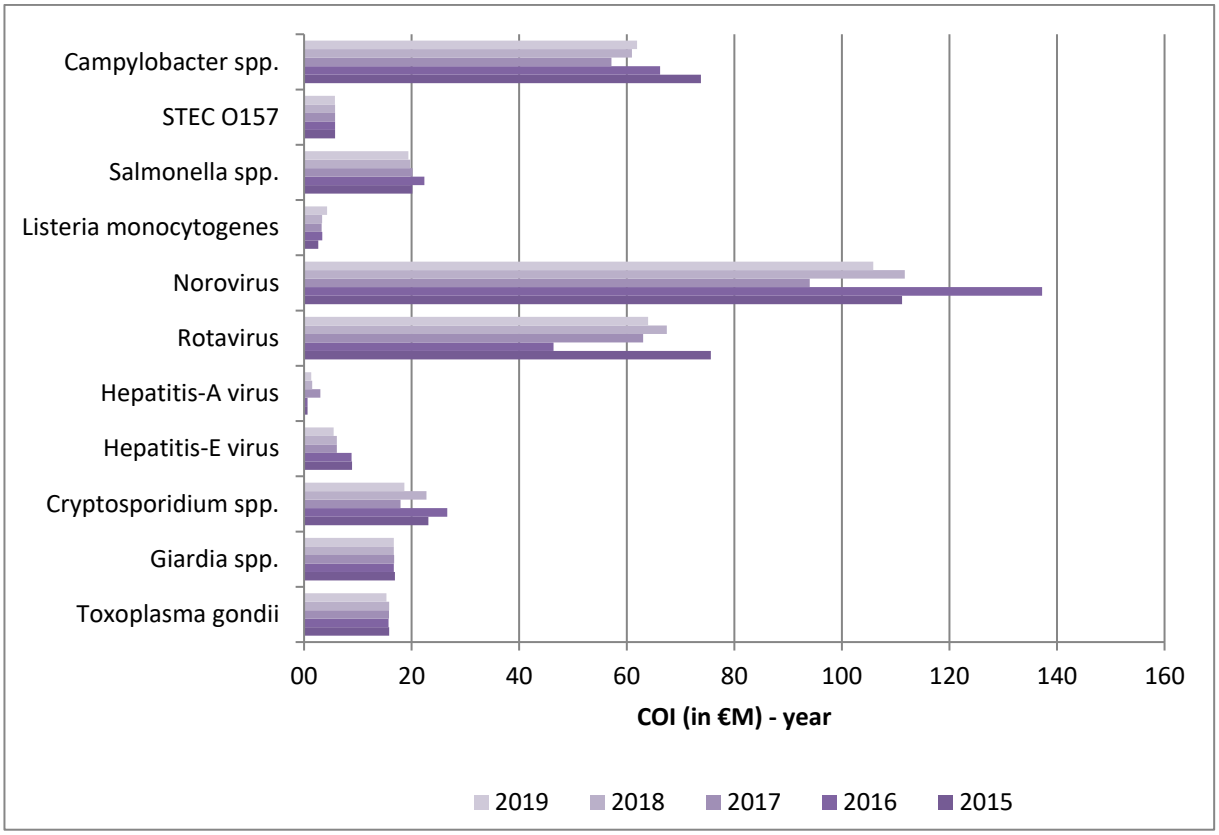

*Figure 5 Comparison of cost-of-illness (M€, discounted at 4% and expressed in 2019 euros) of food-related pathogens in 2015-2019**
* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

2.5 Attribution

The attribution results (expert elicitation) for DALYs and COI of foodborne diseases in 2019 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.6–A.13 in Annex. Foodborne disease burden accounted for 38% of the total burden (i.e. 4,200 DALYs of the total burden of 11,000 DALYs per year), and 41% of the total COI (i.e. 174 M€ of the 423 M€). About 41% of the foodborne burden was associated with meat (i.e. poultry, pork, beef & lamb). These foods caused 33% of all food-related fatal 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 2015-2019 are presented in Tables 10-13. The foodborne disease burden slightly decreased by 100 DALYs from 4,300 DALYs in 2018 to 4,200 DALYs in 2019 and the COI increased by 3 M€ from 171 M€ in 2017 to 174 M€ in 2019.

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, 2019

Main pathway	Food	Environment	Human	Animal	Travel	Total
Number of incident cases (per year) [b]	647,000	193,000	516,000	82,000	133,000	1,570,000
Number of fatal cases (per year) [b]	84	41	68	21	31	245
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	1,800	2,000	910	1,100	9,100
Cost of illness (M€, undiscounted) [c]	197	75	118	33	44	467
Cost of illness (M€, discounted (4%)) [c]	174	62	117	30	41	423

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 foodborne disease[a] to food group in the Netherlands, 2019

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	54,000	21,000	54,000	52,000	38,000	15,000	39,000	121,000	101,000	647,000
Number of fatal cases (per year) [b]	9	9	16	5	7	8	6	2	3	5	12	82
Disease burden (DALY, undiscounted) [b]	530	740	940	200	300	290	270	74	120	220	430	4,100
Disease burden (DALY, discounted (1.5%)) [b]	410	510	810	180	250	250	230	66	110	200	370	3,400
Cost of illness (M€, undiscounted)[c]	30	25	26	7	17	15	12	4	10	28	25	197
Cost of illness (M€, discounted (4%)) [c]	25	16	23	7	15	13	11	4	9	27	23	174

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 2015-2019, total and by pathogen

Pathogen	Incidence/year				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	37,000	33,000	28,000	30,000	31,000
STEC O157	860	860	860	860	850
Salmonella spp.	15,000	18,000	15,000	14,000	14,000
Listeria monocytogenes	50	66	80	54	81
B. cereus toxin	46,000	47,000	47,000	47,000	48,000
C. perfringens toxin	154,000	154,000	155,000	155,000	157,000
S. aureus toxin	251,000	250,000	251,000	251,000	252,000
Norovirus	103,000	128,000	86,000	103,000	98,000
Rotavirus	34,000	18,000	27,000	29,000	27,000
Hepatitis A virus	45	45	55	69	75
Hepatitis E virus	260	260	180	180	160
Cryptosporidium spp.	11,000	13,000	8,200	10,900	8,600
Giardia spp.	11,000	11,000	11,000	11,000	11,000
Toxoplasma gondii	430	430	430	430	430
Total	**663,000**	**673,000**	**629,000**	**652,000**	**647,000**

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).
* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

Table 11 Attribution of mean number of fatal cases to food in the Netherlands for 2015-2019, total and by pathogen

Pathogen	Number of fatal cases/year				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	27	24	21	20	22
STEC O157	2	2	2	2	2
Salmonella spp.	15	18	19	14	13
Listeria monocytogenes	11	8	8	4	11
B. cereus toxin	0	0	0	0	0
C. perfringens toxin	4	4	4	4	4
S. aureus toxin	6	6	6	6	6
Norovirus	11	14	9	11	11
Rotavirus	6	3	5	5	5
Hepatitis A virus	0	0	0	0	0.3
Hepatitis E virus	3	3	2	2	2
Cryptosporidium spp.	1	1	1	1	0.5
Giardia spp.	0	0	0	0	0.3
Toxoplasma gondii	7	7	7	7	7
Total	**93**	**90**	**83**	**76**	**84**

* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

Table 12 Attribution of mean disease burden (DALY per year, undiscounted) to food in the Netherlands for 2015-2019, total and by pathogen

Pathogen	**DALY(undiscounted)/year**				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	1,700	1,500	1,300	1,300	1,400
STEC O157	61	61	61	61	61
Salmonella spp.	640	760	680	620	600
Listeria monocytogenes	170	310	190	180	130
B. cereus toxin	28	28	29	29	29
C. perfringens toxin	180	180	180	180	180
S. aureus toxin	190	190	190	190	190
Norovirus	300	380	270	320	310
Rotavirus	170	88	140	150	150
Hepatitis A virus	5	5	6	8	8
Hepatitis E virus	100	100	70	71	63
Cryptosporidium spp.	19	22	14	19	15
Giardia spp.	29	29	29	28	29
Toxoplasma gondii	1,100	1,100	1,100	1,100	1,000
Total	**4,600**	**4,700**	**4,200**	**4,300**	**4,200**

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).
* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

Table 13 Attribution of mean COI (M€/year discounted at 4% and expressed in 2019 euros) to food in the Netherlands for 2015-2019, total and by pathogen

Pathogen	**COI per year (4%)/year (Million €, expressed in 2019 euros)**				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	30	27	23	25	26
STEC O157	2	2	2	2	2
Salmonella spp.	11	12	11	11	11
Listeria monocytogenes	2	2	2	2	3
B. cereus toxin	10	10	10	10	10
C. perfringens toxin	26	26	26	27	27
S. aureus toxin	52	52	52	53	55
Norovirus	18	22	15	18	18
Rotavirus	9	6	8	9	8
Hepatitis A virus	0.07	0.07	0.3	0.1	0.1
Hepatitis E virus	1	1	0.8	0.8	0.8
Cryptosporidium spp.	3	3	2	3	2
Giardia spp.	2	2	2	2	2
Toxoplasma gondii	8	8	8	9	9
Total	**174**	**173**	**163**	**171**	**174**

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).
* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

3 Discussion

This report provides an integrated public health perspective on the burden of 14 food-related pathogens in the Netherlands. The ranking of foodborne pathogens when using burden of disease metrics is very different compared to ranking based on incidence only. *T. gondii*, *Campylobacter* spp., norovirus and *Salmonella* spp. are the pathogens with the highest burden in the whole population of the Netherlands. *T. gondii* and *L. monocytogenes* are the pathogens with the highest burden at an individual level. We observed an overall decrease in the number of incident cases of the 14 enteric food-related pathogens, especially for norovirus, *Cryptosporidium* spp. and rotavirus. Since, the aforementioned pathogens had a relatively low disease burden per case, the overall burden of disease in 2019 was similar to 2018 (11,000 DALYs). The burden of disease is still lower than in 2015-2016 (range: 12,000 to 14,000 DALYs). Overall, the proportion of foodborne transmission was about 40%, and the attributable burden decreased slightly compared to 2018 (from 4,300 to at 4,200 DALYs). The overall COI slightly decreased and the foodborne-related COI slightly increased in 2019 compared to 2018. This discrepancy in decrease and increase in costs is due to the distribution of cases over the five pathways. In 2019, the incident cases (and burden of disease and costs) of norovirus, rotavirus and *Cryptosporidium spp.* decreased, resulted in less cases in the five pathways. Furthermore, the incident cases of *Campylobacter* spp. increased in 2019, but this mainly attributed to the food pathway. In other words, the cases in the food pathway increased and in the other four pathways decreased.
The slight change of overall burden and overall costs 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. For example, for *T. gondii* there is no trend information. However, we aim to update the incidence estimates of *T.gondii* in the coming year since serological results of the PIENTER3 will become available. Besides the assumed stable incidence of *T.gondii*, there are some more assumptions made for this infectious disease. Firstly, it is uncertain how many congenitally infected children actually experience or develop long-term complication due to this parasite. The actual percentage of infected children that later in life experience problems, and the severity of these complications are uncertain. Secondly, the number of acquired infections with *Toxoplasma* is uncertain. The
(sero-)incidence is based on seroprevalence in the population and this may overestimate the actual occurrence of symptoms due to acquired infections. Updating the incidence of symptoms due to congenitally or acquired infections of *Toxoplasma* requires a new study or (active) surveillance with (long) follow-up time.

Additionally, 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 (i.e. SENSOR study)

conducted in the late 90s. However, as these might not reflect the current situation they should be updated, requiring a new study. We also aim to update some disease models using insights from literature, e.g. the addition of long-term complications of *Cryptosporidium* spp. and *Giardia* spp. infections, and extrahepatic symptoms of hepatitis E. Furthermore, updating the source attribution on the fraction of human *Campylobacter* and *Salmonella* cases that is attributed to the five different major pathways (i.e. food, environment, etc.) is another recommendation for further research.

4 References

1. Havelaar, A.H., et al., Disease burden of foodborne pathogens in the Netherlands, 2009. Int J Food Microbiol, 2012. **156**(3): p. 231-8.
2. Mangen, M.J.J., *Disease burden of food-related pathogens in the Netherlands, 2015*, in *RIVM Letter report 2017-0060*. 2017, National Institute for Public Health and the Environment: Bilthoven. p. 42.
3. Mangen, M.J.J., *Disease burden of food-related pathogens in the Netherlands, 2017*, in *RIVM Letter report 2018-0037*. 2018, National Institute for Public Health and the Environment: Bilthoven. p. 52.
4. Pijnacker, R., *Disease burden of food-related pathogens in the Netherlands, 2018*, in *RIVM Letter report 2019-0086*. 2019, National Institute for Public Health and the Environment: Bilthoven. p. 50.
5. Mangen, M.J.J., *Disease burden of food-related pathogens in the Netherlands, 2016*, in *RIVM Letter report 2017-0097* 2017, National Institute for Public Health and the Environment: Bilthoven. p. 58.
6. Borgen, K., et al., Non-travel related Hepatitis E virus genotype 3 infections in the Netherlands; a case series 2004 - 2006. BMC Infect Dis, 2008. **8**: p. 61.
7. Havelaar, A.H., et al., *Attribution of foodborne pathogens using structured expert elicitation.* Foodborne Pathog Dis, 2008. **5**(5): p. 649-59.

5 Annex: Detailed results

Table A.1 Trends in incidence per 100,000 inhabitants and reported cases, respectively, of food-related pathogens, 1999-2019

Year	Ca[a]	Sa[a]	Cryp[a]	RV[a]	NV[a]	aLm[b]	aLm fatal[b]	pLm[b]	pLm fatal[b]	O157[b]	O157 hosp[b]	HAV[b]	HAV hosp[b]	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
2019	**35**	**9**	**8**	**16**	**25**	**113**	**16**	**4**	**0**	**35**	**13**	**166**	**135[o]**	**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; o) known for 159/166 cases

Table A.2 Mean number of incident cases by pathogen in the Netherlands, 2015-2019

Pathogen	**Estimated mean number of incident cases/year**				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	89,000	79,000	67,000	71,000	73,000
STEC O157	2,100	2,100	2,100	2,100	2,100
Salmonella spp.	27,00	32,000	27,000	27,000	26,000
Listeria monocytogenes	72	96	115	78	120
B. cereus toxin	52,000	52,000	53,000	53,000	53,000
C. perfringens toxin	170,000	171,000	171,000	171,000	173,000
S. aureus toxin	288,000	287,000	287,000	288,000	289,000
Norovirus	615,000	765,000	515,000	615,000	585,000
Rotavirus	261,000	138,000	209,000	224,000	211,000
Hepatitis A virus	390	400	1,800	900	700
Hepatitis E virus	1,900	1,900	1,300	1,300	1,200
Cryptosporidium spp.	92,000	109,000	69,000	91,000	72,000
Giardia spp.	84,000	83,000	83,000	82,000	83,000
Toxoplasma gondii	770	770	770	770	760
Total	**1,680,000**	**1,720,000**	**1,490,000**	**1,630,000**	**1,570,000**

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.

* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

Table A.3 Mean number of fatal cases by pathogen in the Netherlands, 2015-2019

Pathogen	**Estimated mean number of fatal cases/year**				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	65	57	49	47	53
STEC O157	4	4	4	4	4
Salmonella spp.	28	32	34	25	24
Listeria monocytogenes	16	12	12	6	16
B. cereus toxin	0	0	0	0	0
C. perfringens toxin	5	5	5	5	5
S. aureus toxin	7	7	7	7	7
Norovirus	65	82	56	69	66
Rotavirus	43	23	35	38	36
Hepatitis A virus	1	1	6	3	3
Hepatitis E virus	22	21	15	15	13
Cryptosporidium spp.	6	7	4	6	4
Giardia spp.	2	2	2	2	2
Toxoplasma gondii	12	12	12	12	12
Total	**280**	**270**	**240**	**238**	**245**

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.

* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

Table A.4 Mean estimated disease burden (undiscounted DALY/year) in the Netherlands for the years 2015- 2019, total and by pathogen

Pathogen	**DALY(undiscounted)/year**				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	4,000	3,600	3,100	3,200	3,300
STEC O157	150	150	150	150	150
Salmonella spp.	1,200	1,400	1,200	1,100	1,100
Listeria monocytogenes	240	450	280	260	180
B. cereus toxin	32	32	32	32	33
C. perfringens toxin	200	200	200	200	200
S. aureus toxin	220	220	220	220	220
Norovirus	1,800	2,200	1,600	1,900	1,800
Rotavirus	1,300	670	1,100	1,200	1,100
Hepatitis A virus	43	44	200	100	90
Hepatitis E virus	740	740	510	510	460
Cryptosporidium spp.	160	190	120	160	120
Giardia spp.	220	220	220	220	220
Toxoplasma gondii	1,900	1,900	1,900	1,900	1,900
Total	**12,000**	**12,000**	**11,000**	**11,000**	**11,000**

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.
* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

Table A.5 Mean discounted COI (4%) in million euros in the Netherlands for 2015-2019, total and by pathogen

Pathogen	**COI per year (4%)/year (Million €, expressed in 2019 euros)**				
	2015*	**2016**	**2017**	**2018**	**2019**
Campylobacter spp.	72	65	56	60	62
STEC O157	6	6	6	6	6
Salmonella spp.	20	22	20	19	19
Listeria monocytogenes	3	3	3	3	4
B. cereus toxin	11	11	11	11	12
C. perfringens toxin	29	29	29	29	30
S. aureus toxin	61	61	61	61	63
Norovirus	109	134	92	109	106
Rotavirus	74	45	62	66	64
Hepatitis A virus	0.6	0.6	3	1	1
Hepatitis E virus	9	9	6	6	5
Cryptosporidium spp.	23	26	17	22	19
Giardia spp.	16	16	16	16	17
Toxoplasma gondii	15	15	15	15	15
Total	**447**	**443**	**397**	**426**	**423**

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).

* Since the 2017-update new incidence estimates for hepatitis E virus, *Cryptosporidium* spp. and *Giardia* spp. are used, therefore estimates presented here for 2015 are different from the one presented in earlier publications (i.e. [2]).

Table A.6 Attribution of mean estimated number of incident cases by pathogen to main pathways in the Netherlands, 2019

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	31,000	15,000	4,600	14,000	8,800	73,000
STEC O157	850	360	210	430	250	2,100
Salmonella spp.	14,000	3,400	2,400	2,400	3,700	26,000
Listeria monocytogenes	81	8	6	6	16	120
B. cereus toxin	48,000	590	640	590	3,900	53,000
C. perfringens toxin	157,000	3,800	3,600	3,600	5,500	173,000
S. aureus toxin	252,000	10,000	**9,000**	**6,300**	11,000	289,000
Norovirus	98,000	83,000	324,000	29,000	51,000	585,000
Rotavirus	27,000	36,000	122,000	**6,300**	19,000	211,000
Hepatitis A virus	75	73	100	0	390	700
Hepatitis E virus	160	290	88	120	490	1,200
Cryptosporidium spp.	8,600	20,000	20,000	9,700	14,000	72,000
Giardia spp.	11,000	20,000	29,000	8,900	15,000	83,000
Toxoplasma gondii	430	280	7	19	35	760
Total	**647,000**	**193,000**	**516,000**	**82,000**	**133,000**	**1,570,000**

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.7 Attribution of mean estimated number of fatal cases to main pathways in the Netherlands, 2019

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	22	11	3	10	6	53
STEC O157	2	0.7	0.4	0.8	0.5	4.0
Salmonella spp.	13	3	2	2	3	24
Listeria monocytogenes	11	1.1	0.8	0.9	2	16
B. cereus toxin	0	0	0	0	0	0.0
C. perfringens toxin	4	0.1	0.1	0.1	0.1	4.7
S. aureus toxin	6	0.3	0.2	0.2	0.3	7.2
Norovirus	11	9	36	3	6	66
Rotavirus	5	6	21	1	3	36
Hepatitis A virus	0.2	0.2	0.9	0.0	1.2	2.6
Hepatitis E virus	2	3	1	1	6	13
Cryptosporidium spp.	0.5	1	1	0.6	0.9	4.4
Giardia spp.	0.3	0.5	0.8	0.2	0.4	2.3
Toxoplasma gondii	7	4	0.1	0.3	0.5	12
Total	**84**	**41**	**68**	**21**	**31**	**245**

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 disease burden (DALY per year, undiscounted) to main pathways in the Netherlands, 2019

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	1,400	680	210	630	400	3,300
STEC O157	61	26	15	31	18	150
Salmonella spp.	600	140	100	100	160	1,100
Listeria monocytogenes	130	12	10	10	24	180
B. cereus toxin	29	0	0	0	2	33
C. perfringens toxin	180	4	4	4	6	200
S. aureus toxin	190	8	7	5	8	220
Norovirus	310	260	1,020	92	160	1,800
Rotavirus	150	190	650	33	99	1,100
Hepatitis A virus	8	8	30	0	43	90
Hepatitis E virus	63	110	35	49	200	460
Cryptosporidium spp.	15	34	34	17	24	120
Giardia spp.	29	53	76	24	39	220
Toxoplasma gondii	1,000	680	17	47	86	1,900
Total	**4,200**	**2,200**	**2,200**	**1,000**	**1,300**	**11,000**

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.9 Attribution of mean cost-of-illness (M€ per year, discounted at 4% and in 2019 euros) to main pathways in the Netherlands, 2019

Main pathway	Food	Environment	Human	Animal	Travel	Total
Campylobacter spp.	26	13	4	12	7	62
STEC O157	2	1	0.6	1	0.7	6
Salmonella spp.	11	3	2	2	3	19
Listeria monocytogenes	3	0.3	0.2	0.2	0.6	4
B. cereus toxin	10	0.1	0.1	0.1	0.8	12
C. perfringens toxin	27	0.7	0.6	0.6	1.0	30
S. aureus toxin	55	2	2	1	2	63
Norovirus	18	15	59	5	9	106
Rotavirus	8	11	37	2	6	64
Hepatitis A virus	0.1	0.1	1	0.0	0.6	1
Hepatitis E virus	0.0	1	0.4	0.6	2	5
Cryptosporidium spp.	2	5	5	3	4	19
Giardia spp.	2	4	6	2	3	17
Toxoplasma gondii	9	6	0.1	0.4	0.7	15
Total	**174**	**62**	**117**	**30**	**41**	**423**

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.10 Attribution of mean incidence by pathogen to food groups in the Netherlands, 2019

Food groups	Beef & Lamb	Pork	Poultry	Eggs	Dairy	Fish& shellfish	Produce	Beverages	Grains	Other foods	Humans & animals	Total
Campylobacter spp.	1,300	1,600	17,000	950	2,700	2,100	1,600	520	710	1,010	1,600	*31,000*
STEC O157	370	54	26	18	63	25	60	31	25	30	140	*850*
Salmonella spp.	1,800	2,000	2,100	3,100	930	580	890	440	610	850	810	*14,000*
Listeria monocytogenes	9	8	5	3	20	14	6	2	5	5	4	*81*
B. cereus toxin	3,400	1,700	760	1,700	2,700	950	950	800	8,000	25,000	1,100	*47,000*
C. perfringens toxin	75,000	13,000	11,000	4,400	6,400	10,000	11,000	3,900	4,100	12,000	5,600	*156,000*
S. aureus toxin	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	3,100	3,000	2,800	1,800	1,900	15,000	7,100	3,000	5,100	4,900	49,000	*97,000*
Rotavirus	0	770	0	0	470	5,300	6,500	1,200	2,100	1,200	9,800	*27,000*
Hepatitis A virus	0	0	0	0	0	12	12	4	4	3	58	*93*
Hepatitis E virus	0	10	0	0	0	0	1	0	0	0	1	*10*
Cryptosporidium spp.	2,300	380	250	230	790	1,800	1,900	260	0	260	530	*8,600*
Giardia spp.	2,100	520	330	0	830	1,400	3,600	350	0	360	1,300	*11,000*
Toxoplasma gondii	98	210	21	0	20	16	25	0	0	10	24	*430*
Total	**108,000**	**44,000**	**54,000**	**21,000**	**54,000**	**52,000**	**38,000**	**15,000**	**39,000**	**121,000**	**101,000**	**647,000**

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.11 Attribution of mean number of fatal cases by pathogen to food groups in the Netherlands, 2019

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	0.7	1	22
STEC O157	0.7	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.3	1.6
Salmonella spp.	2	2	2	3	1	0.5	1	0.4	0.6	1	1	13
Listeria monocytogenes	1.2	1.0	0.7	0.4	3	2	0.8	0.3	0.7	0.6	0.5	11
B. cereus toxin	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 toxin	2	0.3	0.3	0.1	0.2	0.3	0.3	0.1	0.1	0.3	0.1	4.2
S. aureus toxin	0.5	0.5	0.5	0.2	0.9	0.4	0.1	0.1	0.5	2	0.7	6.2
Norovirus	0.4	0.3	0.3	0.2	0.2	2	0.8	0.3	0.6	0.5	6	11
Rotavirus	0.0	0.1	0.0	0.0	0.1	0.9	1	0.2	0.4	0.2	2	4.7
Hepatitis A virus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
Hepatitis E virus	0.0	1.4	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.2	1.8
Cryptosporidium spp.	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.5
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	6.6
Total	**9**	**10**	**16**	**5**	**7**	**8**	**6**	**2**	**3**	**5**	**12**	**84**

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 disease burden (DALY per year, undiscounted) by pathogen to food groups in the Netherlands, 2019

Food groups	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish& shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	57	71	750	43	123	97	74	24	32	46	74	1,400
STEC O157	27	4	2	1	5	2	4	2	2	2	10	61
Salmonella spp.	76	86	90	130	40	25	38	19	26	36	34	600
Listeria monocytogenes	14	12	8	5	31	22	10	3	7	7	6	130
B. cereus toxin	2	1	0.5	1	2	0.6	0.6	0.5	5	16	0.7	29
C. perfringens toxin	86	15	13	5	7	12	12	5	5	14	6	180
S. aureus toxin	14	16	15	6	28	11	4	3	14	57	23	190
Norovirus	10	10	9	6	6	48	22	10	16	15	160	310
Rotavirus	**0**	4	**0**	**0**	2	28	35	6	11	7	52	150
Hepatitis A virus	0	0	0	0	0	1.0	1.1	0.4	0.4	0.3	5	8
Hepatitis E virus	0	46	0	0	0	3	5	2	0	0	6	63
Cryptosporidium spp.	4	0.7	0.4	0.4	1	3	3	0.4	0	0.4	1	15
Giardia spp.	6	1	0.9	0	2	4	9	0.9	0	0.9	4	29
Toxoplasma gondii	240	520	50	0	48	39	60	0	0	24	59	1,000
Total	**530**	**790**	**940**	**200**	**300**	**290**	**280**	**76**	**120**	**220**	**440**	**4,200**

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.13 Attribution of mean cost-of-illness (M€ per year, discounted at 4% and expressed in 2019 euros) by pathogen to food groups in the Netherlands, 2019[a]

Food groups	**Beef & Lamb**	**Pork**	**Poultry**	**Eggs**	**Dairy**	**Fish& shellfish**	**Produce**	**Beverages**	**Grains**	**Other foods**	**Humans & animals**	**Total**
Campylobacter spp.	1.1	1	14	0.8	2	2	1	0.4	0.6	0.9	1	26
STEC O157	1	0	0	0	0	0	0	0	0	0	0	2
Salmonella spp.	1	2	2	2	0.7	0.4	0.7	0.3	0.5	0.6	0.6	11
Listeria monocytogenes	0.3	0.3	0.2	0.11	0.7	0.5	0.2	0.08	0.2	0.2	0.1	3
B. cereus toxin	0.7	0.4	0.2	0.4	0.6	0.2	0.2	0.2	2	6	0.2	10
C. perfringens toxin	13	2	2	0.8	1	2	2	0.7	0.7	2	1.0	27
S. aureus toxin	4	4	4	2	8	3	1	1.0	4	16	7	55
Norovirus	0.6	0.5	0.5	0.3	0.4	3	1	0.5	0.9	0.9	9	18
Rotavirus	0	0.2	0	0	0	2	2	0.4	0.6	0.4	3	8
Hepatitis A virus	0	1	0	0	0	0.04	0.06	0.026	0.000	0.000	0.08	0.76
Hepatitis E virus	0	0	0	0	0	0	0	0	0	0	0	0
Cryptosporidium spp.	0.6	0.1	0.1	0.1	0.2	0.5	0.5	0.1	0	0.1	0.14	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	4.3	0.4	0.0	0.4	0.3	0.5	0.0	0	0.2	0.5	9
Total	**25**	**16**	**23**	**7**	**15**	**14**	**11**	**4**	**9**	**27**	**23**	**174**

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).

Erratum RIVM briefrapport 2020-0117

Datum: 15 januari 2021
Rapportnummer: 2020-0117
Rapporttitel: Disease burden of food-related pathogens in the Netherlands, 2019

Fouten: Tabel 4 bevat foutieve waarden en de waardes in de rijen komen niet overeen met de namen op de rijen.

Onderstaande tabel is de juiste tabel:

Table 4: Mean estimated number of incident cases and 95% uncertainty interval (between brackets) of gastroenteritis by pathogen in the Netherlands, 2019

Pathogen	**Number of incident cases#**			**Fatal cases#**
	General population (x 1,000)	**GP visit (x 1,000)**	**Hospitalised (x 1,000)**	
All causes	4.860 (4040-5780)	223 (1-225)	22 -	NA#
Bacteria – infectious				
Campylobacter spp.	73 (9.5-198)	18 (8.6-33)	1.1 (0.4-2.1)	53 (35-73)
STEC O157	2.1 (0.2-8.8)	0 (0-0)	0.0 (0.02-0.02)	4 (2-7)
Salmonella spp.	26 (2.4-81)	4 (2-6.5)	1.1 (0.1-0.5)	24 (0-0)
Bacteria – toxin producing				
Bacillus cereus	53 (18-127)	8 (1.7-20)	0.2 (-)	0 (2-4)
Clostridium perfringens	173 (57.3-384)	32 (7.7-84)	0.3 (1-3.2)	5 (27-125)
Staphylococcus aureus	289.0 (124-554)	40 (12-95)	1.5 (0.2-1.2)	7 (0-20)
Viruses				
Norovirus	585 (393-851)	13 (7.6-22)	1.9 (1-3.2)	66 (27-125)
Rotavirus	211.0 (104-382)	12 (7.8-19)	5.5 (4.1-7.4)	36 (11-81)
Protozoa				
Cryptosporidium spp.	72 (22-179)	4 (2.1-7.7)	0.6 (0.2-1.2)	4 (0-20)
Giardia spp.	83 (41-163)	8 (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. 0.0023=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).

RIVM
Committed to *health and sustainability*