

## Foodborne Illness—Major Pathogens, Expanded Tables

**Table 1. Modeling approaches used to estimate the total number of illnesses for different types of data, United States\***

Pathogens for which laboratory-confirmed illnesses were scaled up			Pathogens for which US population was scaled down
Active surveillance data	Passive surveillance data	Outbreak surveillance data	
<i>Campylobacter</i> spp.	<i>Brucella</i> spp.	<i>Bacillus cereus</i>	Astrovirus
<i>Cryptosporidium</i> spp.	<i>Clostridium botulinum</i>	<i>Clostridium perfringens</i>	Norovirus
<i>Cyclospora cayetanensis</i>	<i>Giardia intestinalis</i>	ETEC <sup>†</sup>	Rotavirus
STEC O157	Hepatitis A virus	<i>Staphylococcus aureus</i>	Sapovirus
STEC non-O157	<i>Mycobacterium bovis</i>	<i>Streptococcus</i> spp. group A	<i>Toxoplasma gondii</i>
<i>Listeria monocytogenes</i>	<i>Trichinella</i> spp.		
<i>Salmonella</i> spp., nontyphoidal <sup>‡</sup>	<i>Vibrio cholerae</i> , toxigenic		
<i>S. enterica</i> serotype Typhi	<i>Vibrio parahaemolyticus</i>		
<i>Shigella</i> spp.	<i>Vibrio vulnificus</i>		
<i>Yersinia enterocolitica</i>	<i>Vibrio</i> spp., other		

\*ETEC, enterotoxigenic *Escherichia coli*; STEC, Shiga toxin–producing *E. coli*.

<sup>†</sup>Numbers of *E. coli* other than STEC or ETEC assumed to be same as for ETEC.

<sup>‡</sup>Includes all serotypes other than Typhi.

# Foodborne Illness—Major Pathogens, Expanded Tables

**Table 2. Estimated annual number of episodes of illnesses caused by 31 pathogens, United States\***

Pathogen	Laboratory-confirmed	Multipliers		Total, mean (90% CrI)	Travel-related, percentage	Domestically acquired, mean (90% CrI)	Foodborne, percentages§	Domestically acquired foodborne, mean (90% CrI)
		Under-reporting†	Under-diagnosis‡					
<b>Bacteria</b>								
<i>Bacillus cereus</i> , foodborne¶	85 <sup>§</sup>	25.5	29.3	63,623 (15,770–147,827)	<1	63,411 (15,721–147,380)	100	63,400 (15,719–147,354)
<i>Brucella</i> spp.	120 <sup>**</sup>	1.1	15.2	2,003 (1,302–2,964)	16	1,679 (1,089–2,484)	50	839 (533–1,262)
<i>Campylobacter</i> spp.	43,696 <sup>††</sup>	1.0	30.3	1,322,137 (530,126–2,521,026)	20	1,058,387 (423,255–2,019,498)	80	845,024 (337,031–1,611,083)
<i>Clostridium botulinum</i> , foodborne¶	25 <sup>**</sup>	1.1	2.0	56 (34–92)	<1	55 (34–91)	100	55 (34–91)
<i>Clostridium perfringens</i> , foodborne¶	1,295 <sup>§</sup>	25.5	29.3	969,342 (192,977–2,492,003)	<1	966,120 (192,331–2,483,682)	100	965,958 (192,316–2,483,309)
STEC O157	3,704 <sup>††</sup>	1.0	26.1	96,534 (26,982–227,891)	4	93,094 (26,046–219,676)	68	63,153 (17,587–149,631)
STEC non-O157	1,579 <sup>††</sup>	1.0	106.8	168,698 (17,163–428,522)	18	138,063 (14,080–350,891)	82	112,752 (11,467–287,321)
ETEC, foodborne¶	53 <sup>§</sup>	25.5	29.3	39,781 (53–102,250)	55	17,897 (24–46,215)	100	17,894 (24–46,212)
Diarrheagenic <i>E. coli</i> other than STEC and ETEC	53	25.5	29.3	39,871 (53–102,378)	<1	39,739 (52–102,028)	30	11,982 (16–30,913)
<i>Listeria monocytogenes</i>	808 <sup>††</sup>	1.0	2.1	1,662 (582–3,302)	3	1,607 (563–3,193)	99	1,591 (557–3,161)
<i>Mycobacterium bovis</i>	195 <sup>††</sup>	1.0	1.1	208 (177–241)	70	63 (49–78)	95	60 (46–74)
<i>Salmonella</i> spp., nontyphoidal‡‡	41,930 <sup>††</sup>	1.0	29.3	1,229,007 (772,129–2,008,076)	11	1,095,079 (687,126–1,790,225)	94	1,027,561 (644,786–1,679,667)
<i>S. enterica</i> serotype Typhi	433 <sup>††</sup>	1.0	13.3	5,752 (299–17,357)	67	1,897 (91–5,756)	96	1,821 (87–5,522)
<i>Shigella</i> spp.	14,864 <sup>††</sup>	1.0	33.3	494,908 (93,877–1,420,877)	15	421,048 (79,844–1,208,445)	31	131,254 (24,511–374,789)
<i>Staphylococcus aureus</i> , foodborne¶	323 <sup>§§</sup>	25.5	29.3	241,994 (72,584–531,398)	<1	241,188 (72,352–529,509)	100	241,148 (72,341–529,417)
<i>Streptococcus</i> spp. group A, foodborne¶	15 <sup>§</sup>	25.5	29.3	11,257 (15–78,104)	<1	11,219 (15–77,875)	100	11,217 (15–77,875)
<i>Vibrio cholerae</i> , toxigenic	8 <sup>**</sup>	1.1	33.1	277 (94–630)	70	84 (19–212)	100	84 (19–213)
<i>V. vulnificus</i>	111 <sup>**</sup>	1.1	1.7	207 (138–287)	2	203 (136–281)	47	96 (60–139)
<i>V. parahaemolyticus</i>	287 <sup>**</sup>	1.1	142.4	44,950 (23,706–74,984)	10	40,309 (21,277–67,282)	86	34,664 (18,260–58,027)
<i>Vibrio</i> spp., other	220 <sup>**</sup>	1.1	142.7	34,585 (21,756–51,535)	11	30,727 (19,278–45,886)	57	17,564 (10,848–26,475)
<i>Yersinia enterocolitica</i>	950 <sup>††</sup>	1.0	122.8	116,716 (36,363–204,898)	7	108,490 (33,797–190,605)	90	97,656 (30,388–172,734)
<b>Subtotal</b>				<b>4,883,568 (3,160,412–7,148,360)</b>		<b>4,330,358 (2,771,307–6,438,919)</b>		<b>3,645,773 (2,321,468–5,581,290)</b>
<b>Parasites</b>								
<i>Cryptosporidium</i> spp.	7,594 <sup>††</sup>	1.0	98.6	748,123 (162,961–2,135,110)	9	678,828 (147,796–1,940,626)	8	57,616 (12,060–166,771)
<i>Cyclospora cayetanensis</i>	239 <sup>††</sup>	1.0	83.1	19,808 (239–65,135)	42	11,522 (139–38,031)	99	11,407 (137–37,673)
<i>Giardia intestinalis</i>	20,305 <sup>**</sup>	1.3	46.3	1,221,564 (892,393–1,633,965)	8	1,121,864 (818,627–1,501,290)	7	76,840 (51,148–109,739)
<i>Toxoplasma gondii</i>		1.0	0	173,995 (134,593–218,866)	<1	173,415 (134,172–218,169)	50	86,686 (64,861–111,912)
<i>Trichinella</i> spp.	13 <sup>**</sup>	1.3	9.8	162 (44–355)	4	156 (42–341)	100	156 (42–341)
<b>Subtotal</b>				<b>2,163,652 (1,401,591–3,596,566)</b>		<b>1,985,785 (1,292,817–3,290,175)</b>		<b>232,705 (161,923–369,893)</b>
<b>Viruses</b>								
Astrovirus	NA	NA	NA	3,090,384 (2,350,589–3,833,232)	0	3,089,868 (2,350,263–3,832,706)	<1	15,433 (5,569–26,643)
Hepatitis A virus	3,576 <sup>**</sup>	1.1	9.1	35,769 (21,505–60,715)	41	21,041 (12,455–35,918)	7	1,566 (702–3,024)
Norovirus	NA	NA	NA	20,865,958 (12,842,072–30,743,963)	<1	20,796,079 (12,798,628–30,638,633)	26	5,461,731 (3,227,078–8,309,480)
Rotavirus	NA	NA	NA	3,090,384 (2,350,589–3,833,232)	0	3,089,868 (2,350,263–3,832,706)	<1	15,433 (5,569–26,643)
Sapovirus	NA	NA	NA	3,090,384 (2,350,589–3,833,232)	0	3,089,868 (2,350,263–3,832,706)	<1	15,433 (5,569–26,643)
<b>Subtotal</b>				<b>30,172,879 (21,795,012–40,272,501)</b>		<b>30,086,723 (21,733,225–40,154,878)</b>		<b>5,509,597 (3,273,623–8,355,568)</b>
<b>TOTAL</b>				<b>37,220,098 (28,434,745–47,630,066)</b>		<b>36,402,867 (27,698,948–46,716,681)</b>		<b>9,388,075 (6,641,440–12,745,709)</b>

\*All estimates were based on US population in 2006. Modal or mean value shown unless otherwise stated; see online Technical Appendix 3 ([www.cdc.gov/EID/content/17/1/7-Techapp3.pdf](http://www.cdc.gov/EID/content/17/1/7-Techapp3.pdf)) for the parameters of these distributions. The credible interval (CrI) lower bound for total illnesses was replaced with the number of laboratory-confirmed illnesses when that lower bound was zero. The observed lower bound was then carried forward using the travel-related and foodborne percentages. STEC, Shiga toxin-producing *Escherichia coli*; ETEC, enterotoxigenic *E. coli*; NA, not applicable.

†Adjustment for underreporting because of surveillance method; underreporting multiplier for passive surveillance systems (Cholera and Other *Vibrio* Illness Surveillance [COVIS] or the National Notifiable Disease Surveillance System [NNDSS]) derived by comparing the incidence of laboratory-confirmed illnesses for *Listeria*, non-typhoidal *Salmonella* spp., *Shigella*, and STEC O157 (for bacteria) and *Cryptosporidium* spp. and *Cyclospora cayetanensis* (for parasites) ascertained in the Foodborne Diseases Active Surveillance Network (FoodNet) to the incidence of laboratory-confirmed illnesses for the same pathogens reportable to NNDSS; underreporting multiplier for outbreak-associated illness reported through the Foodborne Disease Outbreak Surveillance System (FDOSS) derived by comparing the incidence of laboratory-confirmed illnesses caused by *Campylobacter* spp., *Cryptosporidium* spp., *Cyclospora cayetanensis*, STEC, *Listeria monocytogenes*, *Salmonella* spp., *Shigella* spp., *Vibrio* spp., and *Yersinia enterocolitica* ascertained in FoodNet to the incidence of laboratory-confirmed illnesses of these bacterial infections reported to FDOSS. The modal value is presented here; online Technical Appendix 3 has the low and high values of these PERT distributions. More detail on the data used to estimate underreporting multipliers is given in online Technical Appendix 4 ([www.cdc.gov/EID/content/17/1/7-Techapp4.pdf](http://www.cdc.gov/EID/content/17/1/7-Techapp4.pdf)).

‡Adjustment for underdiagnosis because of variations in medical care seeking, specimen submission, laboratory testing, and test sensitivity. The modal value is presented here; online Technical Appendix 3 describes the low and high values of these PERT distributions.

§Percent foodborne among domestically acquired illnesses.

¶Estimates based on the number of foodborne illnesses ascertained in surveillance and therefore assumed to reflect only foodborne transmission.

#Passive surveillance data on outbreak-associated illnesses from FDOSS.

\*\*Passive surveillance data from COVIS or NNDSS.

††Active surveillance data from FoodNet, adjusted for geographical coverage; data from the NTSS for *M. bovis*.

‡‡For all analyses in this article, *S. enterica* serotype *Paratyphi* is grouped with nontyphoidal *Salmonella* spp.



## Foodborne Illness—Major Pathogens, Expanded Tables

**Table 3. Estimated annual number of hospitalizations and deaths caused by 31 pathogens, United States\***

Pathogen	Estimated annual number of hospitalizations			Estimated annual number of deaths		
	Hospitalization rate, %†	Total, mean (90% CrI)	Domestically acquired foodborne, mean (90% CrI)	Death rate, %†	Total, mean (90% CrI)	Domestically acquired foodborne, mean (90% CrI)
<b>Bacteria</b>						
<i>Bacillus cereus</i> , foodborne‡	0.4	20 (0–86)	20 (0–85)	0	0	0
<i>Brucella</i> spp.	55.0	132 (79–197)	55 (33–84)	0.9	2 (1–4)	1 (0–2)
<i>Campylobacter</i> spp.	17.1	13,240 (6,770–23,827)	8,463 (4,300–15,227)	0.1	119 (0–523)	76 (0–332)
<i>Clostridium botulinum</i> , foodborne‡	82.6	42 (19–77)	42 (19–77)	17.3	9 (0–51)	9 (0–51)
<i>Clostridium perfringens</i> , foodborne‡	0.6	439 (45–2,015)	438 (44–2,008)	<0.1	26 (0–163)	26 (0–163)
STEC O157	46.2	3,268 (844–7,052)	2,138 (549–4,614)	0.5	31 (0–173)	20 (0–113)
STEC non-O157	12.8	405 (0–1,451)	271 (0–971)	0.3	0§	0§
ETEC, foodborne‡	0.8	26 (0–119)	12 (0–53)	0	0	0
<i>Diarrheagenic E. coli</i> other than STEC and ETEC	0.8	26 (0–120)	8 (0–36)	0	0	0
<i>Listeria monocytogenes</i>	94.0	1,520 (544–3,152)	1,455 (521–3,018)	15.9	266 (0–765)	255 (0–733)
<i>Mycobacterium bovis</i>	55.0	108 (79–140)	31 (21–42)	4.7	9 (8–11)	3 (2–3)
<i>Salmonella</i> spp., nontyphoidal	27.2	23,128 (10,221–44,860)	19,336 (8,545–37,490)	0.5	452 (0–1,210)	378 (0–1,011)
<i>S. enterica</i> serotype Typhi	75.7	623 (0–1,848)	197 (0–583)	0	0	0
<i>Shigella</i> spp.	20.2	5,491 (1,100–13,741)	1,456 (287–3,695)	0.1	38 (0–254)	10 (0–67)
<i>Staphylococcus aureus</i> , foodborne‡	6.4	1,067 (173–3,006)	1,064 (173–2,997)	<0.1	6 (0–48)	6 (0–48)
<i>Streptococcus</i> spp. group A, foodborne‡	0.2	1 (0–6)	1 (0–6)	0	0	0
<i>Vibrio cholerae</i> , toxigenic	43.1	7 (0–16)	2 (0–5)	0	0	0
<i>V. vulnificus</i>	91.3	202 (120–303)	93 (53–145)	34.8	77 (43–120)	36 (19–57)
<i>V. parahaemolyticus</i>	22.5	129 (66–219)	100 (50–169)	0.9	5 (0–22)	4 (0–17)
<i>Vibrio</i> spp., other	37.1	163 (101–240)	83 (51–124)	3.7	16 (6–36)	8 (3–19)
<i>Yersinia enterocolitica</i>	34.4	637 (0–1,396)	533 (0–1,173)	2.0	34 (0–206)	29 (0–173)
Subtotal		50,673 (30,578–75,466)	35,796 (21,519–53,414)		1,093 (358–2,247)	861 (260–1,761)
<b>Parasites</b>						
<i>Cryptosporidium</i> spp.	25.0	2,725 (777–6,558)	210 (58–518)	0.3	46 (0–241)	4 (0–19)
<i>Cyclospora cayentanensis</i>	6.5	20 (0–190)	11 (0–109)	0.0	0	0
<i>Giardia intestinalis</i>	8.8	3,581 (2,414–4,822)	225 (141–325)	0.1	34 (18–51)	2 (1–3)
<i>Toxoplasma gondii</i>	2.6	8,889 (5,383–13,203)	4,428 (2,634–6,674)	0.2	656 (409–952)	327 (200–482)
<i>Trichinella</i> spp.	24.3	6 (0–18)	6 (0–17)	0.2	0	0
Subtotal		15,221 (10,617–20,867)	4,881 (3,060–7,146)		736 (456–1,094)	333 (205–488)
<b>Viruses</b>						
Astrovirus	0.4	17,430 (10,203–21,573)	87 (32–147)	<0.1	5 (1–9)	0
Hepatitis A virus	31.5	2,255 (1,250–3,953)	99 (42–193)	2.4	171 (94–299)	7 (3–15)
Norovirus	0.03	56,013 (32,197–86,569)	14,663 (8,097–23,323)	<0.1	571 (331–881)	149 (84–237)
Rotavirus	1.7	69,721 (55,958–84,348)	348 (128–586)	<0.1	32 (23–40)	0
Sapovirus	0.4	17,430 (13,990–21,087)	87 (32–147)	<0.1	5 (1–9)	0
Subtotal		162,850 (130,126–199,658)	15,284 (8,719–23,962)		783 (522–1,112)	157 (91–245)
<b>Total</b>		<b>228,744 (188,326–275,601)</b>	<b>55,961 (39,534–75,741)</b>		<b>2,612 (1,723–3,819)</b>	<b>1,351 (712–2,268)</b>

\*All estimates were based on US population in 2006. CrI, credible interval; STEC, Shiga toxin–producing *Escherichia coli*; ETEC, enterotoxigenic *E. coli*.

†For laboratory-confirmed illnesses. Unadjusted hospitalization and death rates are presented. These rates were doubled to adjust for underdiagnosis before being applied to the number of laboratory-confirmed cases to estimate the total number of hospitalizations and deaths. The hospitalization and death rates for astrovirus, norovirus, rotavirus, and sapovirus are the percent of total estimated illness and were not subject to further adjustment.

‡Estimates based on the number of foodborne illnesses ascertained in surveillance and therefore assumed to reflect only foodborne transmission.

§We report median values instead of means for the distributions of deaths caused by STEC non-O157 because of extremely skewed data.