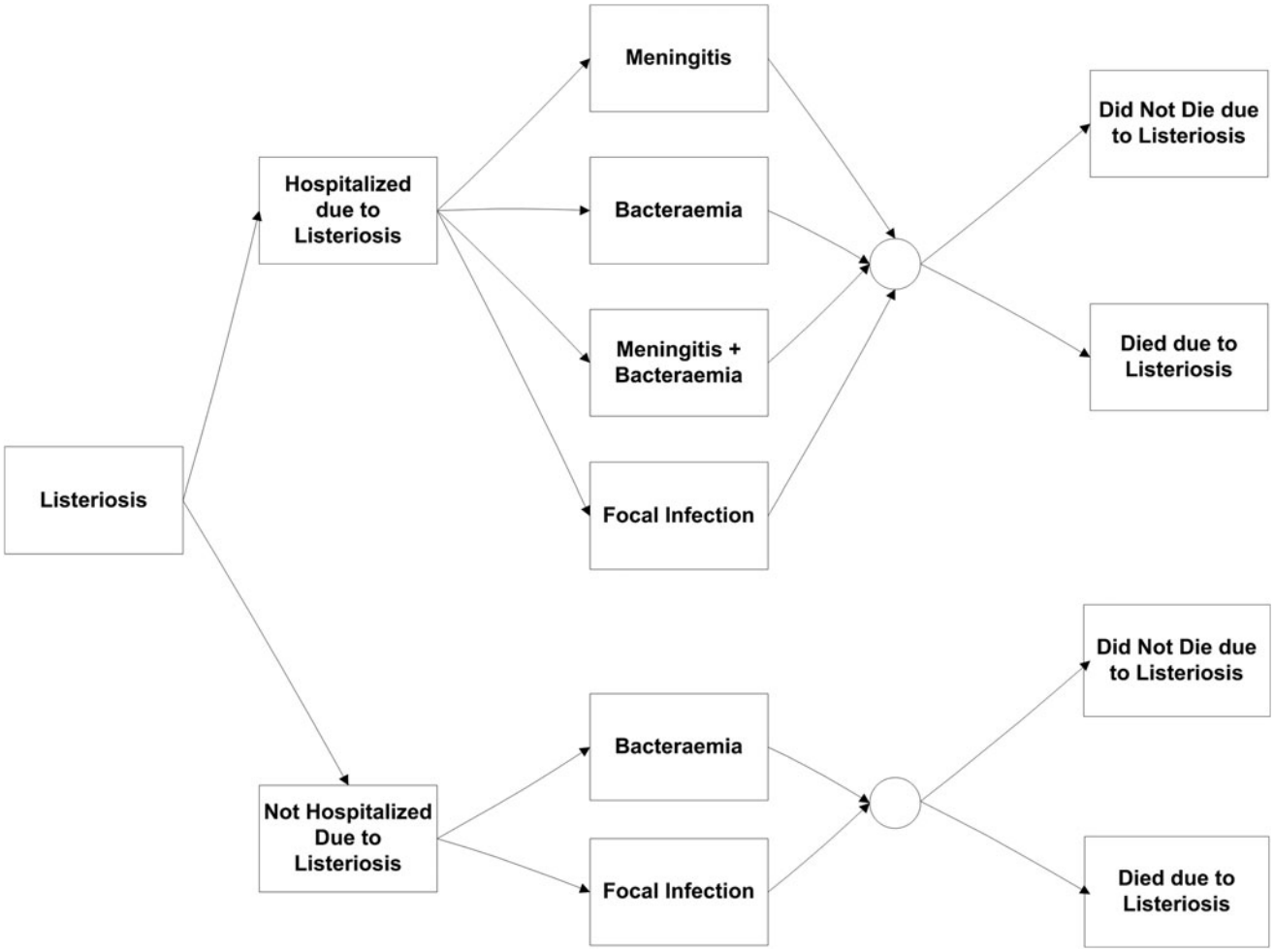
Supplementary Data

Supplementary Data S1: Case Costs—Methodology, Inputs, and Data Sources

The costs associated with affected individuals are classified into three categories: Direct Healthcare Costs (DHC), Direct Non-Healthcare Costs (DNHC), and Indirect Non-Healthcare Costs (INHC). The burden associated with deaths is estimated in two ways. The value of a statistical life (VSL), which in this study is a Canadian-specific estimate of society's willingness to pay to prevent one death, is used to estimate the value that society places on the lives lost due to this outbreak. An example from Chestnut and De Civita (Chestnut and De Civita, 2009) is useful in illustrating this concept: suppose a study finds that, on average, individuals state that they are willing to pay $60 to reduce their annual risk of death from contaminated meat from 3 in 100,000 to 2 in 100,000 (a 1 in 100,000 risk reduction). In aggregate this risk reduction amounts to 1 less expected death in a sample of 100,000 people, or 1 statistical life saved. The individual dollar amount totaled over 100,000 people yields an estimate of $6 million for 1 statistical life; this is referred to as the ''value of statistical life'' (VSL). The VSL is sometimes referred to as a ''cost'' of a death, as it is often used in cost–benefit analyses to represent the monetary value of statistical lives saved due to a particular intervention, and by extension is sometimes used as a monetary measure of the value that society places on lives lost due to disease. It is important to remember, however, that in essence the VSL is not the value of a single individual's life, but rather the sum of the value that society places on reductions in risk. Alternatively, disability adjusted life years (DALYs) provide an estimate of the burden associated with pain, suffering, and loss of life in terms of years lost, rather than estimating this burden in monetary terms. For a detailed description of the DALY methodology, see Supplementary Data S4.

For each case, the following variables were extracted from the outbreak dataset (Currie *et al*., 2015) for this analysis: age, gender, province, symptom onset date (estimated by specimen collection date for four cases where onset date was not applicable or available), hospitalization as a result of listeriosis, hospital admission and discharge dates (where reported), clinical presentation and symptoms, institutional setting prior to illness (i.e., resident of a long-term care facility, hospital in-patient), whether or not the case died and if so, whether or not listeriosis caused or contributed to the death (Supplementary Fig. S1.1).



SUPPLEMENTARY FIG. S1.1. Disease outcome tree for the 57 confirmed listeriosis cases in this outbreak.

Direct healthcare costs

Costs in this category include medical services such as hospital fees, general practice (GP) consultations, specialist consultations, treatments, and diagnostic tests (Supplementary Figs. S1.2 and S1.3).

Formally and closely following the methodology found in Kemmeren *et al.* (Kemmeren *et al*., 2006), direct healthcare costs are estimated according to the following formula:

$$\mathrm{DHC} = \Sigma_l\{\Sigma_i(m_\mathrm{i} \times p_\mathrm{i} \times mc_\mathrm{i})\}$$

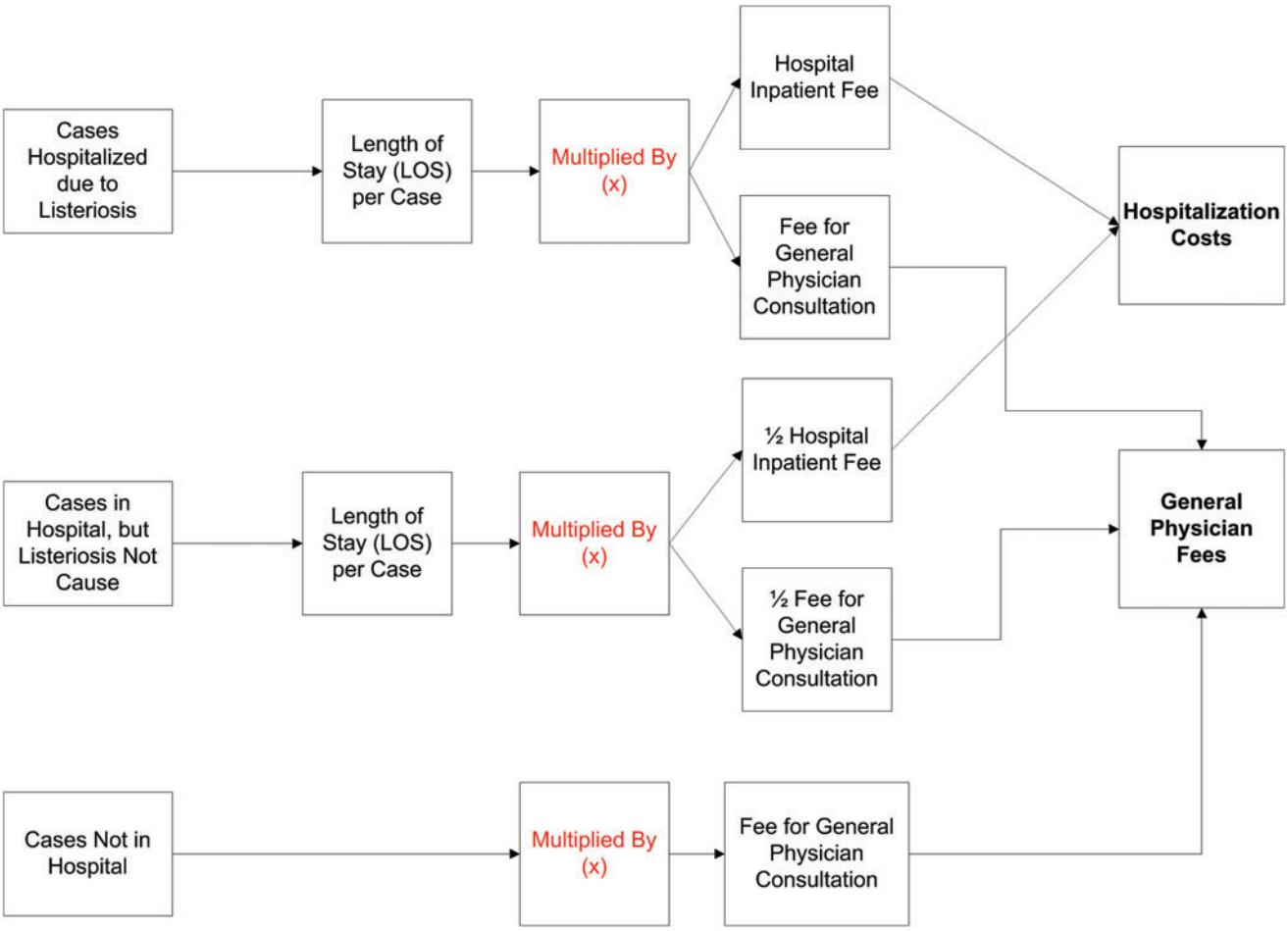
where m is the number of cases requiring a particular service, p is the required units of the healthcare service per case, and mc is the unit cost of the healthcare service, summed across all health outcomes l and all healthcare services i.

Data sources: Direct Healthcare Costs

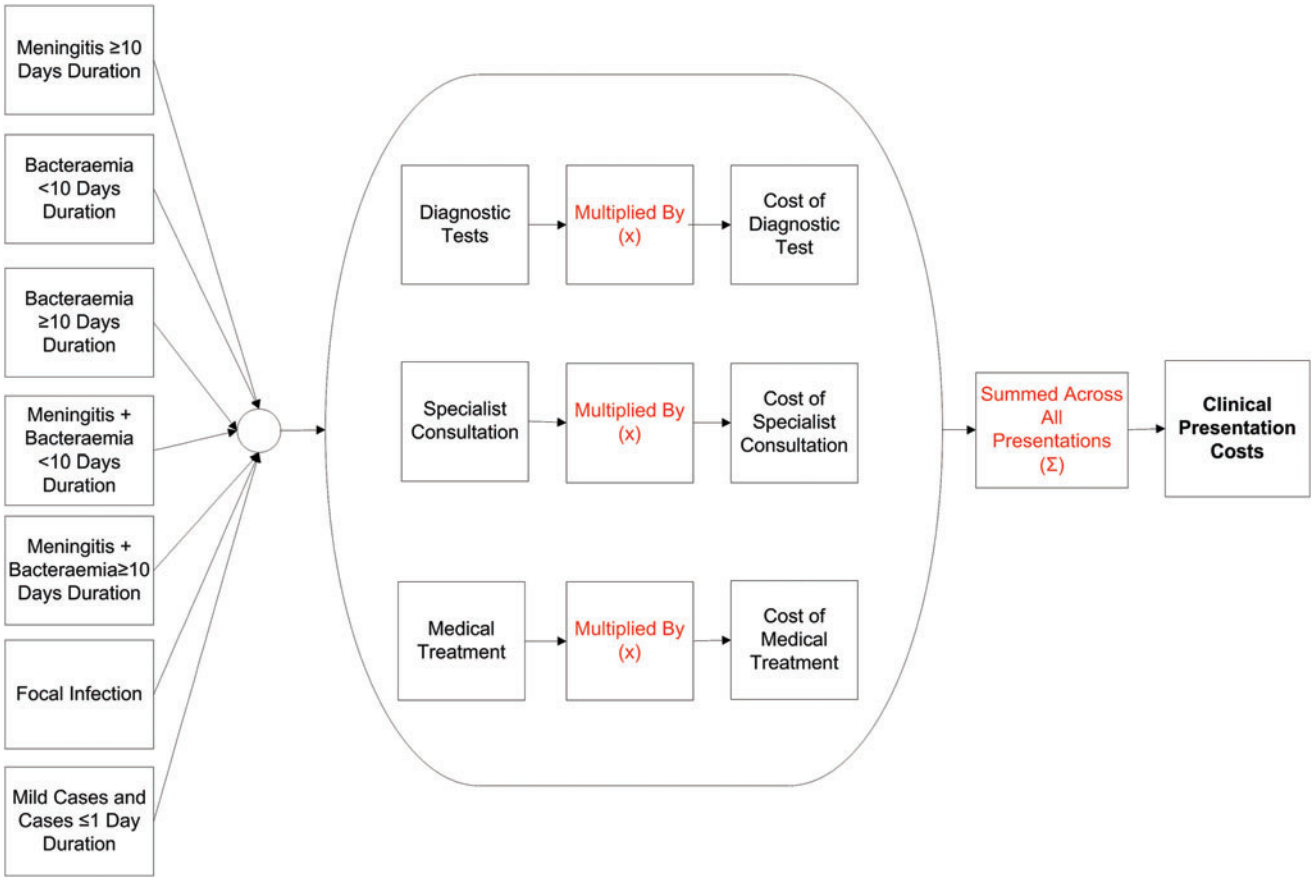
Detailed in the tables below are various data sources and inputs used to develop the direct healthcare costs associated with the 2008 listeriosis outbreak. This section includes cost details for diagnostic procedures, consultations with general practitioner and specialists, and medical treatments. Some listings include both a Professional Component (P) and a Technical Component (H). Where both components are listed, they are totaled to arrive at a cost estimate for that procedure. Laboratory diagnostic tests are valued as a certain number of LMS (labor, materials, supervision) units (Ontario Ministry of Health and Long-Term Care, 1999). LMS units are valued at $0.517 per unit (Supplementary Table S1.1).

The costs listed denote the Drug Benefit Price (DBP), or the cost of drugs covered by the Ontario Ministry of Health and Long Term Care (Ontario Ministry of Health and Long-Term Care, 2003). If the medications were administered in hospitals, it was assumed that the DBP represents the cost. In cases where medications were not administered in hospital (i.e., were purchased at a pharmacy), an 8% wholesale markup value (Patented Medicine Prices Review Board, 2012) was added to the DBP, based on the maximum allowable markup on the DBP allowed by the Ontario Drug Benefit Program. This is the maximum refundable markup on pharmaceuticals allowed in Ontario.

The cost of surgical procedures includes a fee for surgical services (Surg), as well as fees for surgical assistants' services (Asst) and anesthesiologists' services (Anae). The Surg component is recorded as a dollar value, whereas assistants and anesthesiologists are accorded a certain number of billable units depending on the procedure. Assistant units are currently valued at $11.52, and anesthesiology units are currently valued at $15.01 per unit (Supplementary Tables S1.1.1–1.1.3).



SUPPLEMENTARY FIG. S1.2. Visualization of hospital and general practitioner fee calculation.



SUPPLEMENTARY FIG. S1.3. Visualization of diagnostic, specialist, and treatment cost calculation.

The following tables (Supplementary Tables S1.1.4–S1.1.14) provide details related to diagnostic testing, medical practitioner consultations and treatments for each of the specific set of outcomes experienced by the cases (Supplementary Fig. S1.3). For each case, information is available on diagnosis and symptoms but no details were provided on the consultations and treatments received. Thus, these scenarios were generated to approximate values for the actual cases. Review by an infectious diseases physician specializing in listeriosis was conducted to verify inputs as being appropriate.

SUPPLEMENTARY TABLE S1.1. DIRECT HEALTHCARE COSTS

Model input	*Data source(s)*	*Distribution*	*Parameters*
Number of cases hospitalized due to listeriosis	Forty-seven cases were hospitalized due to listeriosis (Currie *et al*., 2015).	Constant	47
Number of cases not hospitalized due to listeriosis	The remaining 10 cases were not hospitalized due to listeriosis (Currie *et al.*, 2015).	Constant	10
Length of stay (LOS), cases hospitalized due to listeriosis	Duration of hospitalization per case as described in the national outbreak dataset (Currie *et al.*, 2015). If hospitalization occurred prior to onset of listeriosis, LOS is calculated as the length of time from the onset date until discharge or death. If hospitalization occurred after the onset date of listeriosis, LOS is calculated as the length of time from admission to discharge or death.	Constant (if known) PERT (if unknown)	Varies by case Low, most likely, high values
	In cases where the duration of hospitalization due to listeriosis cannot be established ($n = 14$, i.e., where there are no data regarding discharge date, duration of multiple hospitalizations, or the symptom onset date was unclear), then the minimum, most likely, and maximum LOS values for nonpregnancy-associated cases of listeriosis by age and gender as reported by the Canadian Institute of Health Information (Canadian Institute for Health Information) are used as a proxy in a PERT distribution.		(Varies by age and gender)
LOS, cases not hospitalized due to listeriosis	There were 10 cases that were not hospitalized due to listeriosis. For 5 of these individuals, there was no available data to indicate that they were hospitalized and no LOS was attributed (2 individuals died ≤1 day after symptom onset; 2 individuals were in long-term care facilities, and 1 was a hospital outpatient). Five of the individuals were hospitalized due to other reasons. There was no available data to clarify whether or not some of their hospital stay was attributed to listeriosis. Therefore, for these cases, LOS was calculated from symptom onset date to discharge or death. For 1 of these cases that was known to be hospitalized at the time of onset but for whom no data about onset or discharge dates were available, the minimum, most likely, and maximum LOS values for nonpregnancy-associated cases of listeriosis by age and gender as reported by the Canadian Institute of Health Information (Canadian Institute for Health Information) are used as a proxy in a PERT distribution.		

(*continued*)

SUPPLEMENTARY TABLE S1.1. (CONTINUED)

Model input	*Data source(s)*	*Distribution*	*Parameters*
Total duration of illness	Individual PERT distributions are constructed for each case that did not result in death, with the actual duration of hospitalization (LOS) as the minimum estimate (assuming no additional time ill). The most likely estimate adds an additional 0.71 days of illness for each hospitalized day, based on the CDC cost of illness calculator for *Salmonella* (Hoffmann *et al*., 2012; USDA Economic Research Service, 2011). The maximum estimate of an additional 3 days for each hospitalized day is based on the Economic Research Service Model (Buzby *et al*., 1996). For cases that died, with or without listeriosis as a contributing factor to death, no additional time ill is attributed and the duration is assumed to be the length of hospital stay (described above). Total duration of illness is the sum of the PERT distributions for nondeceased cases, and the reported duration of hospitalization for deceased cases.	PERT (Alive) Constant (Deceased)	Low, most likely, high values (LOS, LOS*1.71, LOS*3) Varies by case
Hospital stay costs (per day)	Estimates derived from the Ontario Ministry of Health and Long-Term Care's *Schedule A 2007/08 Ontario Hospital Interprovincial Per Diem Rates for Inpatient Services*, which lists the daily hospital fees of 156 Ontario hospitals in 2008 (Ontario Ministry of Health and Long-Term Care, 2008). For cases that were hospitalized due to listeriosis, the above fee distribution was applied for each day of hospital LOS. For cases that were not hospitalized due to listeriosis but to whom some hospital LOS was attributed, one half (1/2) of the above fee distribution was applied to each day of hospitalization. This reflects the complicating nature of listeriosis, which may have indirectly contributed to or extended hospital stay.	Log logistic	Shift, β, α (0, 794.22, 6.2797)
General practitioner (GP) consultation fees per day	See Supplementary Table S1.1.1. Fees are adjusted to 2008 prices.	Constant (First visit) Repeat visit	$72.19 $42.92
GP fees— cases hospitalized due to listeriosis	Assumed 1 general physician consultation per day of hospitalization for each case, calculated by multiplying the total LOS by the fee for a consultation with a general practitioner. The first consultation is valued at the cost for a general consultation, and subsequent consultations are valued at the cost of a repeat consultation (this applies throughout).		

(*continued*)

SUPPLEMENTARY TABLE S1.1. (CONTINUED)

Model input	*Data source(s)*	*Distribution*	*Parameters*
GP fees– cases not hospitalized due to listeriosis	For cases that were not hospitalized due to listeriosis but to whom some hospital LOS was attributed, the estimate allowed for 1 GP consultation per day of hospitalization. The fees for these consultations were valued at one half (1/2) of the above fees listed in Supplementary Table S1.1.1, to reflect that a general physician was not likely to be managing listeriosis for these patients directly. For cases that were deceased ≤1 day after symptom onset ($n=2$), it was assumed that patients would have one (1) consultation with a GP. For those with mild clinical presentations ($n=3$), the number of physician consultations was modeled in a PERT distribution. These were also valued at one half (1/2) of the above fees listed in Supplementary Table S1.1.1.	PERT (Number of GP visits for mild cases)	Low, most likely, high values (1, 5, 7)
Diagnosis/laboratory fees	See Supplementary Table S1.1.2. Fees are adjusted to 2008 prices.	Constant	Varies by procedure
Diagnosis distribution—meningitis ≥10 days duration	See Supplementary Table S1.1.4.	PERT	Low, most likely, high values ($178.88, $296.69, $410.62)
Diagnosis distribution—bacteremia <10 days duration	See Supplementary Table S1.1.5	Constant	$36.94
Diagnosis distribution—bacteremia ≥10 days duration	See Supplementary Table S1.1.6	Constant	$36.94
Diagnosis distribution—meningitis + bacteremia <10 days duration	See Supplementary Table S1.1.7	PERT	Low, most likely, high values ($137.09, $208.01, $276.60)
Diagnosis distribution—meningitis + bacteremia ≥10 days duration	See Supplementary Table S1.1.8	PERT	Low, most likely, high values ($178.88, $296.69, $410.62)
Diagnosis distribution—focal infection	See Supplementary Tables S1.1.9–S1.1.12	Constant PERT (Cerebellar lesion)	$66.65 Low, most likely, high values ($59.42, $276.60, $400.93)
Diagnosis distribution—mild presentation	See Supplementary Table S1.1.13	Constant	$36.94
Diagnosis distribution—duration of illness ≤1 day	See Supplementary Table S1.1.14	Constant	$36.94
Specialist consultation fees	See Supplementary Table S1.1.1. Fees are adjusted to 2008 prices.	Constant	Varies by specialist

(*continued*)

SUPPLEMENTARY TABLE S1.1. (CONTINUED)

Model input	*Data source(s)*	*Distribution*	*Parameters*
Specialist distribution—meningitis ≥10 days duration	See Supplementary Table S1.1.4	PERT	Low, most likely, high values ($293.61, $1172.21, $4141.26)
Specialist distribution—bacteremia <10 days duration	See Supplementary Table S1.1.5	PERT	Low, most likely, high values ($293.61, $581.71, $2156.37)
Specialist distribution—bacteremia ≥10 days duration	See Supplementary Table S1.1.6	PERT	Low, most likely, high values ($293.61, $1172.21, $2943.71)
Specialist distribution—meningitis + bacteremia <10 days duration	See Supplementary Table S1.1.7	PERT	Low, most likely, high values ($293.61, $1172.21, $4141.26)
Specialist distribution—meningitis + bacteremia ≥10 days duration	See Supplementary Table S1.1.8	PERT	Low, most likely, high values ($293.61, $746.61, $3036.18)
Specialist distribution—focal infection	See Supplementary Tables S1.1.9–S1.1.12	PERT (Cerebellar lesion)	Low, most likely, high values ($549.61, $1654.85, $4141.26)
		PERT (Elbow lesion)	Low, most likely, high values ($293.61, $490.45, $687.28)
		PERT (Others)	Low, most likely, high values ($293.61, $1172.21, $3214.78)
Specialist distribution—mild presentation	It was assumed that cases with mild clinical presentations would not consult with specialists.		
Specialist distribution—duration of illness ≤1 day	It was assumed that cases with ≤1 day duration of illness would not consult with specialists.		
Treatment cost	See Supplementary Table S1.1.3. Fees are adjusted to 2008 prices.	Constant	Varies by treatment
Treatment distribution—meningitis ≥10 days duration	See Supplementary Table S1.1.4	PERT	Low, most likely, high values ($185.55, $502.14, $884.72)
Treatment distribution—bacteremia <10 days duration	See Supplementary Table S1.1.5	Constant	$30.42
Treatment distribution—bacteremia ≥10 days duration	See Supplementary Table S1.1.6	PERT	Low, most likely, high values ($45.17, $109.07, $182.81)
Treatment distribution—meningitis + bacteremia <10 days duration	See Supplementary Table S1.1.7	Constant	$124.01

(*continued*)

SUPPLEMENTARY TABLE S1.1. (CONTINUED)

Model input	*Data source(s)*	*Distribution*	*Parameters*
Treatment distribution—meningitis + bacteremia ≥10 days duration	See Supplementary Table S1.1.8	PERT	Low, most likely, high values ($185.55, $502.14, $554.72)
Treatment distribution – mild presentation	See Supplementary Table S1.1.13	PERT	Low, most likely, high values ($0.00, $4.54, $12.71)
Treatment distribution—focal infection	See Supplementary Tables S1.1.9–S1.1.12	PERT (Elbow lesion)	Low, most likely, high values ($0.00, $25.12, $36.24)
		PERT (Knee lesion)	Low, most likely, high values ($45.17, $109.07, $550.00)
		PERT (Hip lesion)	Low, most likely, high values ($45.17, $109.07, $658.60)
		PERT (Cerebellar lesion)	Low, most likely, high values ($185.55, $502.14, $2699.17)
Treatment distribution—duration of illness ≤1 day	It was assumed that cases with ≤1 day duration of illness would not receive medical treatment.		
Chronic sequelae	To estimate the potential presence of sequelae resulting from listeriosis infection, it is first assumed that sequelae only resulted from *Listeria* meningitis (Kemmeren *et al.*, 2006). Of the 10 cases of meningitis reported in the outbreak, 5 cases survived. Prevalence of sequelae is estimated for these 5 cases. Proportions of listerial meningitis cases developing sequelae are extracted from several published clinical cohort studies of adult listeriosis cases (Samuelsson *et al.*, 1990; Skogberg *et al.*, 1992; Büla *et al.*, 1995; Aouaj *et al.*, 2002). The proportions ranged from 0% to 14%, though the proportion for meningitis encephalitis is much higher (57%) (Büla *et al.*, 1995). However, as encephalitic meningitis is very rare compared to uncomplicated meningitis (Edmond *et al.*, 2010), it is assumed that all cases in this study had uncomplicated meningitis. The proportion of meningococcal meningitis patients experiencing sequelae (9.5%), drawn from a meta-analysis of clinical studies, falls within this lower range (Edmond *et al.*, 2010). When these proportions are applied to the surviving meningitis cases in this outbreak, it is estimated that <1 person would be likely to develop any sequelae. Therefore, chronic sequelae and associated costs are excluded from this analysis.		
Notes	Comorbidity is accounted for in terms of additional diagnostic tests, specialist consultations, and medical treatments. However, due to the complicating effects of multiple clinical presentations, it is likely that these costs underestimate the true costs of medical care.		
Adjustments	All adjustments to 2008 prices are made using the Canadian Consumer Price Index (CPI). Physician fees and laboratory expenses are adjusted using the ''Health Care'' component of the CPI, whereas medications are adjusted using the ''Prescribed Medicines'' component. Wages are adjusted using the Bank of Canada's Inflation adjustment tool (Bank of Canada, 2013), as this takes into account the change in all consumer prices and therefore measures the change in general purchasing power of wages across years (Bank of Canada, 2013). Adjustments are made according to the formula: $P_2 = P_1 * (\frac{CPI\ Year\ 2}{CPI\ Year\ 1})$, where P_1 is the price in constant dollars in a known year, P_2 is the price in 2008, *CPI Year 2* is the value of the CPI in 2008, and *CPI Year* 1 is the value of the CPI in the known year in which the price was originally measured. CPI data are drawn from Statistics Canada CANSIM Table 326-0020 (Statistics Canada, 2013a). Prices are simply adjusted for inflation; all other assumptions remain the same, including preferences, discount rates, and taxes. It is possible that these measures may have changed in other ways.		

Supplementary Table S1.1.1. Data Sources for General Practitioner and Specialist Consultations[a]

Variable	*Section heading*	*Official title/code (if applicable)*	*Monetary value*
A. Consultations and Visits			
General physician consultation	Family Practice & Practice in General (00) GENERAL LISTINGS; NONEMERGENCY HOSPITAL IN-PATIENT SERVICES	A005 Consultation; C005 Consultation	$77.20; $77.20
General physician repeat consultation		A006 Repeat consultation; C005 Repeat consultation	$45.90; $45.90
Internal medicine specialist consultation	Internal and Occupations Medicine (13) NONEMERGENCY HOSPITAL IN-PATIENT SERVICES	C135 Consultation	$157.00
Internal medicine specialist repeat consultation		C135 Repeat consultation	$105.25
Infectious disease specialist consultation	Infectious Disease (46) NONEMERGENCY HOSPITAL IN-PATIENT SERVICES	C465 Consultation	$157.00
Infectious disease specialist repeat consultation		C466 Repeat consultation	$105.25
Neurology specialist consultation	Neurology (18) NONEMERGENCY HOSPITAL IN-PATIENT SERVICES	C185 Consultation	$176.35
Neurology specialist repeat consultation		C186 Repeat consultation	$84.95
Orthopedic surgeon consultation	Orthopaedic Surgery (06) NONEMERGENCY HOSPITAL IN-PATIENT SERVICES	C065 Consultation	$83.10
Orthopedic surgeon repeat consultation		C066 Repeat consultation	$51.70

[a]Source: Schedule of Benefits for Physician Services under the Health Insurance Act *(Ontario Ministry of Health and Long-Term Care)* (Ontario Ministry of Health and Long-Term Care, 2013b)

SUPPLEMENTARY TABLE S1.1.2. DATA SOURCES FOR DIAGNOSTIC PROCEDURES

Variable	*Section heading*	*Official title/code (if applicable)*	*Monetary value*
Source: Schedule of Benefits for Laboratory Services *(Ontario Ministry of Health and Long-Term Care)* (Ontario Ministry of Health and Long-Term Care, 1999)			
Blood cultures	MICROBIOLOGY Cultures	L624 Blood (including aerobic, anaerobic, subcultures, smears) per bottle	30 LMS
Fluid or cerebrospinal fluid (CSF) cultures	MICROBIOLOGY Cultures	L639 Fluids (CSF, joint, pleural, etc., not exudates)	28 LMS
Other swabs	MICROBIOLOGY Cultures	L628 Other swabs or pus—culture and smear (includes screening)	25 LMS
Complete blood count (CBC)	HEMATOLOGY	L393 Complete blood count (any method)	16 LMS
CSF cell count/ differential CSF	HEMATOLOGY	L391 CSF cell count (to include differential)	18 LMS
Source: Schedule of Benefits for Physician Services under the Health Insurance Act *(Ontario Ministry of Health and Long-Term Care)* (Ontario Ministry of Health and Long-Term Care, 2013d) D. Diagnostic Radiology			
CT scan (head)	Computed tomography (CT) head	X188—with and without IV contrast	H: — P: $75.85
Source: Schedule of Benefits for Physician Services under the Health Insurance Act *(Ontario Ministry of Health and Long-Term Care)* (Ontario Ministry of Health and Long-Term Care, 2013a) F. Magnetic Resonance Imaging (MRI)			
MRI (Head)	Head	X421—multislice sequence	H: — P: $73.35
Source: Schedule of Benefits for Physician Services under the Health Insurance Act *(Ontario Ministry of Health and Long-Term Care)* (Ontario Ministry of Health and Long-Term Care, 2013c) J. Diagnostic and Therapeutic Procedures			
Intravenous fee (adult)	Injections or infusions INTRAVENOUS	G379 Child, adolescent or adult	$6.15
Lumbar puncture	Neurology	Z804 Lumbar puncture	$67.60

LMS, labor, materials, supervision; H, technical component; P, professional component.

SUPPLEMENTARY TABLE S1.1.3. DATA SOURCES FOR MEDICAL TREATMENTS

Variable	*Section heading*	*Official title/code (if applicable)*	*Monetary value*
Source: Ontario Drug Benefit Formulary/Comparative Drug Index (Ontario Ministry of Health and Long-Term Care, 2003)			
Ampicillin (500 mg capsule)	08:00 ANTI-INFECTIVE AGENTS 08:12:16 ANTIBIOTICS PENICILLINS	AMPICILLIN 50 500 mg Cap	\$0.1588
Ampicillin (50 mg/mL intravenous)		AMPICILLIN 52 50 mg/mL	\$0.0262
Gentamicin (80 mg/2 mL intravenous)	08:00 ANTI-INFECTIVE AGENTS 08:12:28 ANTIBIOTICS OTHER ANTIBIOTICS	GENTAMICIN SULFATE 102 80 mg/2 mL Inj Sol-2 mL Pk	\$3.9600
Source: Schedule of Benefits for Physician Services under the Health Insurance Act *(Ontario Ministry of Health and Long-Term Care)* (Ontario Ministry of Health and Long-Term Care, 2013e) N. Musculoskeletal System Surgical Procedures			
Surgical drainage of elbow joint	Elbow and Forearm INCISION AND DRAINAGE	R445 Elbow	Asst: 6 Surg: \$223.65 Anes: 7
Surgical drainage of hip joint	Pelvis and Hip INCISION AND DRAINAGE	R415 Joint	Asst: 6 Surg:\$301.60 Anes: 7
Surgical drainage of knee joint	Knee INCISION AND DRAINAGE	R444 Joint	Asst: 6 Surg: \$193.00 Anes: 7
Source: Schedule of Benefits for Physician Services under the Health Insurance Act *(Ontario Ministry of Health and Long-Term Care)* (Ontario Ministry of Health and Long-Term Care, 2013f) X. Neurological Surgical Procedures			
Craniotomy for brain abscess	INTRACRANIAL ABSCESS	N117 Craniotomy	Asst: 15 Surg:\$1416.50 Anes: 15

SUPPLEMENTARY TABLE S1.1.4. COST CONSIDERATIONS FOR PATIENTS WITH MENINGITIS (≥10 DAYS DURATION, $N=4$)

Diagnosis	
Tests	Blood cultures, cerebrospinal fluid (CSF) cultures, complete blood count (CBC), differential CSF count, computed tomography (CT) scan (head), magnetic resonance imaging (MRI)
Min	• Blood culture + CSF cultures + CBC + differential CSF count
Most likely	• Blood culture + CSF cultures + CBC + differential CSF count + CT scan
Max	• Blood culture + CSF cultures + CBC + differential CSF count + CT scan + MRI
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease, neurology
Min	• 1 internal medicine, 1 infectious disease
Most likely	• 1 emergency; 5 internal medicine, 5 infectious disease (1 per day for 5 days)
Max	• 1 emergency; 14 internal medicine, 14 infectious disease, 14 neurology (1 per day for 14 days)
Treatment	
Treatments	Ampicillin, gentamicin
Min	• Ampicillin: 8 g/day, 10 days; gentamicin: 300 mg/day, 10 days
Most likely	• Ampicillin: 10 g/day, 21 days; gentamicin: 400 mg/day, 21 days
Max	• Ampicillin: 12 g/day, 30 days; gentamicin: 500 mg/day, 30 days

Supplementary Table S1.1.5. Cost Considerations for Patients with Bacteremia (<10 Days Duration)

Bacteremia (<10 days duration) $n = 17$	
Diagnosis	
Tests	Blood cultures, complete blood count (CBC)
Most likely	Blood culture + CBC
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease
Min	1 internal medicine, 1 infectious disease
Most likely	1 emergency; 2 internal medicine, 2 infectious disease
Max	1 emergency; 10 internal medicine, 10 infectious disease (1 per day for maximum duration of illness)
Treatment	
Treatments	Ampicillin
Most likely	Ampicillin: 10 g/day, 5 days (average duration of illness)

Supplementary Table S1.1.6. Cost Considerations for Patients with Bacteremia (≥10 Days Duration, $N = 20$)

Diagnosis	
Tests	Blood cultures, complete blood count (CBC)
Most likely	Blood culture + CBC
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease
Min	• 1 internal medicine, 1 infectious disease
Most likely	• 1 emergency, 5 internal medicine, 5 infectious disease (1 per day for 5 days)
Max	• 1 emergency; 14 internal medicine, 14 infectious disease (1 per day for 14 days)
Treatment	
Treatments	Ampicillin, gentamicin
Min	• Ampicillin: 8 g/day, 10 days; gentamicin: 300 mg/day, 10 days
Most likely	• Ampicillin: 10 g/day, 21 days; gentamicin: 400 mg/day, 21 days
Max	• Ampicillin: 12 g/day, 30 days; gentamicin: 500 mg/day, 30 days

Supplementary Table S1.1.7. Cost Considerations for Patients with Both Meningitis and Bacteremia (<10 Days Duration; $N = 2$)

Diagnosis	
Tests	Blood cultures, cerebrospinal fluid (CSF) cultures, complete blood count (CBC), differential CSF count, computed tomography (CT) scan (head), magnetic resonance imaging (MRI)
Min	• Blood culture + CSF cultures + CBC + differential CSF count
Most likely	• Blood culture + CSF cultures + CBC + differential CSF count + CT scan
Max	• Blood culture + CSF cultures + CBC + differential CSF count + CT scan + MRI
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease, neurology
Min	• 1 internal medicine, 1 infectious disease
Most likely	• 1 emergency; 2 internal medicine, 2 infectious disease, 2 neurology
Max	• 1 emergency; 10 internal medicine, 10 infectious disease, 10 neurology (1 per day for maximum duration of illness)
Treatment	
Treatments	Ampicillin, gentamicin
Most likely	Ampicillin: 10 g/day, 5 days; gentamicin: 400 mg/day, 5 days (average duration of illness)

Supplementary Table S1.1.8. Cost Considerations for Patients with Both Meningitis and Bacteremia (≥10 Days Duration, $N=2$)

Diagnosis	
Tests	Blood cultures, cerebrospinal fluid (CSF) cultures, complete blood count (CBC), differential CSF count, computed tomography (CT) scan (head), magnetic resonance imaging (MRI)
Min	• Blood culture + CSF cultures + CBC + differential CSF count
Most likely	• Blood culture + CSF cultures + CBC + differential CSF count + CT scan
Max	• Blood culture + CSF cultures + CBC + differential CSF count + CT scan + MRI
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease, neurology
Min	• 1 internal medicine, 1 infectious disease
Most likely	• 1 emergency, 5 internal medicine, 5 infectious disease (1 per day for 5 days)
Max	• 1 emergency, 14 internal medicine, 14 infectious disease, 14 neurology (1 per day for 14 days)
Treatment	
Treatments	Ampicillin, gentamicin
Min	• Ampicillin: 8 g/day, 10 days; gentamicin: 300 mg/day, 10 days
Most likely	• Ampicillin: 10 g/day, 21 days; gentamicin: 400 mg/day, 21 days
Max	• Ampicillin: 12 g/day, 30 days; gentamicin: 500 mg/day, 30 days

Supplementary Table S1.1.9. Cost Considerations for Patients with Focal Infection in Elbow ($N=1$)

Tests	Blood cultures, fluids culture (joint, pleural etc.), other swabs
Most likely	Blood culture + fluids culture + other swabs
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease
Min	• 1 internal medicine, 1 infectious disease
Most likely	• 2 internal medicine; 2 infectious disease
Max	• 1 emergency; 3 internal medicine; 3 infectious disease
Treatment	
Treatments	Ampicillin
Min	• No treatment
Most likely	• Ampicillin: 10 g/day, 3 days; 1500 mg/day, 10 days
Max	• Ampicillin: 12 g/day, 3 days; 2000 mg/day, 21 days

Supplementary Table S1.1.10. Cost Considerations for Patients with Focal Infection in Knee ($N=1$)

Diagnosis	
Tests	Blood cultures, fluids culture (joint, pleural, etc.), other swabs
Most likely	Blood culture + fluids culture + other swabs
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease, orthopedic surgeon
Min	• 1 internal medicine, 1 infectious disease
Most likely	• 1 emergency; 5 internal medicine, 5 infectious disease (1 per day for 5 days)
Max	• 1 emergency; 5 orthopedic surgeon; 14 internal medicine, 14 infectious disease (1 per day for 14 days)
Treatment	
Treatments	Ampicillin, surgical drainage of joint
Min	• Ampicillin: 8 g/day, 10 days
Most likely	• Ampicillin: 10 g/day, 21 days
Max	• Ampicillin: 12 g/day, 30 days; surgical drainage of knee joint

Supplementary Table S1.1.11. Cost Considerations for Patients with Focal Infection in Hip ($N=1$)

Diagnosis	
Tests	Blood cultures, fluids culture (joint, pleural, etc.), other swabs
Most likely	Blood culture + fluids culture + other swabs
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease, orthopedic surgeon
Min	• 1 internal medicine, 1 infectious disease
Most likely	• 1 emergency; 5 internal medicine, 5 infectious disease (1 per day for 5 days)
Max	• 1 emergency; 5 orthopedic surgeon; 14 internal medicine, 14 infectious disease (1 per day for 14 days)
Treatment	
Treatments	Ampicillin, surgical drainage of joint
Min	• Ampicillin: 8 g/day, 10 days;
Most likely	• Ampicillin: 10 g/day, 21 days;
Max	• Ampicillin: 12 g/day, 30 days; surgical drainage of hip joint

Supplementary Table S1.1.12. Cost Considerations for Patients with Focal Infection in Brain (Cerebellar Abscess) ($N=1$)

Diagnosis	
Tests	Blood cultures, complete blood count (CBC), fluids culture (joint, pleural, etc.), cerebrospinal fluid (CSF) cultures, computed tomography (CT) scan, magnetic resonance imaging (MRI)
Min	• Blood culture + complete blood count (CBC) + fluids culture (joint, pleural, etc.)
Most likely	• Blood culture + complete blood count (CBC) + fluids culture (joint, pleural etc.) + CSF culture + CT scan + MRI
Max	• Blood culture + complete blood count (CBC) + fluids culture (joint, pleural etc.) + CSF culture + 3 CT scans + 3 MRIs
Specialist consultations	
Specialists	Emergency, internal medicine, infectious disease, neurology
Min	• 1 emergency, 1 internal medicine, 1 infectious disease, 1 neurology
Most likely	• 1 emergency; 5 internal medicine, 5 infectious disease, 5 neurology (1 per day for 5 days)
Max	• 1 emergency; 5 orthopedic surgeon; 14 internal medicine, 14 infectious disease, 14 neurology (1 per day for 14 days)
Treatment	
Treatments	Ampicillin, gentamicin, surgery
Min	Ampicillin: 8 g/day, 10 days; gentamicin: 300 mg/day, 10 days
Most likely	Ampicillin: 10 g/day, 21 days; gentamicin: 400 mg/day, 21 days
Max	Ampicillin: 12 g/day, 30 days; gentamicin: 500 mg/day, 30 days; craniotomy

Supplementary Table S1.1.13. Cost Considerations for Patients with Mild clinical Presentation ($N=2$)

Mild clinical presentation (incidental finding or asymptomatic)	
Diagnosis	
Tests	Blood cultures, complete blood count (CBC), fluids culture (joint, pleural etc.), cerebrospinal fluid cultures, computed tomography scan, magnetic resonance imaging
Most likely	Blood culture + CBC
Specialist consultations	
Specialists	N/A
Treatment	
Treatments	Ampicillin
Min	No treatment
Most likely	Ampicillin: 1500 mg/day, 10 days
Max	Ampicillin: 2000 mg/day, 21 days

N/A, not applicable.

SUPPLEMENTARY TABLE S1.1.14. COST CONSIDERATIONS FOR PATIENTS WITH DURATION OF ILLNESS ≤1 DAY ($N=6$)

Diagnosis	
Tests	Blood cultures, complete blood count (CBC)
Most likely	Blood culture + CBC
Specialist consultations	
Specialists	N/A
Treatment	
Treatments	N/A

N/A, not applicable.

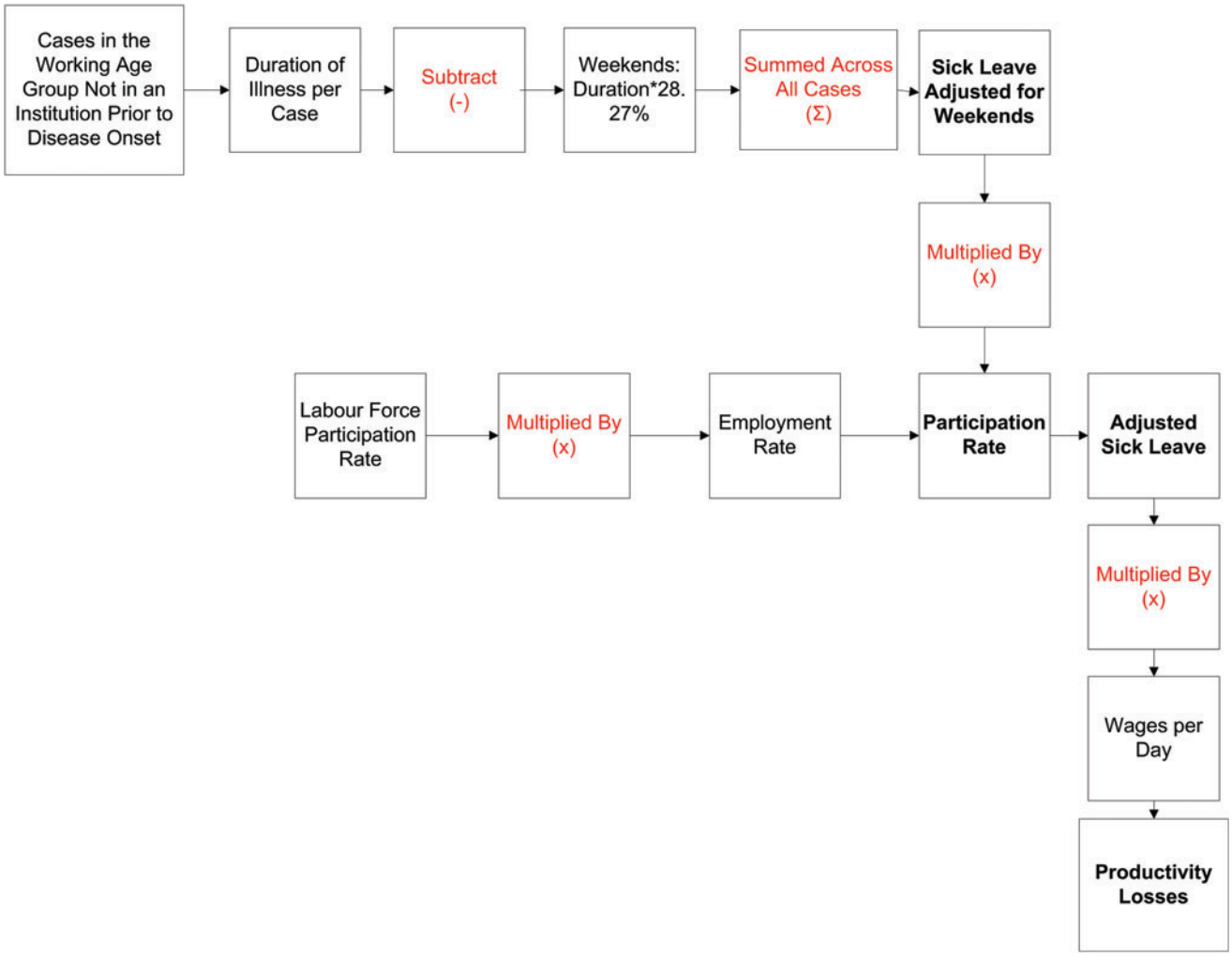
Indirect non-healthcare costs (INHC)

This category considers the production loss to society due to illness (Supplementary Fig. S1.4). These production losses could result from temporary absences from paid employment, long-term or permanent disability, or death (Kemmeren *et al*., 2006). Since very limited data exist regarding long-term disability stemming from listeriosis, and since it was assumed no cases in this outbreak experienced sequelae, sickness leave due to these reasons is not considered. It is assumed that patients in the working age group (ages 15–64) that were not in an institution such as a hospital or long-term care facility prior to illness were required to take time away from work, regardless of health outcome. As none of the patients in this report that fit these criteria died, it was assumed that they returned to work following a period of illness and no further production losses occurred. As there were no deaths in this group, there was no basis for calculating long-term losses of productivity to society, and so productivity losses were calculated for the duration of illness only.

Formally, indirect healthcare costs are estimated according to the formula:

$$\mathrm{INHC} = \Sigma_l\{\Sigma_k(s_k \times u_k \times v_k)\}$$

where s is the number of cases requiring sickness leave, u is the duration of sickness leave, and v is the estimated wages per day, totaled across all health outcomes l and all episodes of sickness leave k (Supplementary Tables S1.2 and S1.2.1).



SUPPLEMENTARY FIG. S1.4. Visualization of indirect non-healthcare cost calculation.

SUPPLEMENTARY TABLE S1.2. INDIRECT NON-HEALTHCARE COSTS

Model inputs	*Data source(s)*	*Distribution*	*Parameters*
Cases requiring sick leave	Number of cases in the working age group (15–64 years) who were not known to be in an institution (hospital, long-term care facility) prior to acquiring *Listeria* (Currie *et al.*, 2015).	Constant	6
Total duration of sick leave per case	For cases with listeriosis as a contributing cause of hospitalization, total duration of sick leave was estimated for each individual in a PERT distribution, with the actual duration of hospitalization (length of stay) as the minimum estimate (assuming no additional time ill). The most likely estimate of an additional 0.71 days of illness for each hospitalized day, based on the CDC cost-of-illness calculator for *Salmonella* (USDA Economic Research Service, 2011; Hoffmann *et al.*, 2012). The maximum estimate of an additional 3 days for each hospitalized day is based on the Economic Research Service Model (Buzby *et al.*, 1996). For one of the cases in the working-age group, there was no evidence of hospitalization (listeriosis was reported as an incidental finding). As such, the duration of sick leave for this individual was assumed to be zero.	PERT	Low, most likely, high values (LOS, LOS*1.71, LOS*3)
Weekend days	The likely number of weekend days over the course of illness for each individual case was estimated. See Supplementary Table S1.2.1 for calculation.		
Sick leave adjusted for weekends	The likely number of weekend days is subtracted from each total duration of sick leave estimate.		
Labor force participation	The labor force participation rate represents the proportion of Canadians that were either employed or unemployed and seeking employment in 2008. See Supplementary Table S1.2.1 for data sources.	Constant	78.5%
Employment rate	Some individuals that are in the labor force are not employed. This proportion is represented by the unemployment rate; one minus this rate is the employment rate. See Supplementary Table 1.2.1 for data sources.	Constant	93.9%
Participation rate	The product of the ''Labor Force Participation Rate'' and the ''Employment Rate'' captures the likelihood that individuals in the working age group had paid employment at the time of onset of listeriosis.	Constant	73.7%

(*continued*)

SUPPLEMENTARY TABLE S1.2. (CONTINUED)

Model inputs	*Data source(s)*	*Distribution*	*Parameters*
Adjusted sick leave	The product of Sick Leave Adjusted for Weekends and the Participation Rate provides a measure of the total number of days that individuals were absent from paid employment as a result of illness.		
Wages per year	Annual wage data is fitted to a lognormal distribution, truncated at the minimum wage in 2008 See Supplementary Table S1.2.1 for data sources. This methodology is consistent with Majowicz *et al.* (Majowicz *et al.*, 2006). Wages are adjusted to 2008 prices.	Truncated Lognormal	Min, mean, standard deviation 16471.875, 32585.1585, 27136.62954
Wages per day	An estimate of the economic cost of 1 day of missed paid employment, calculated by dividing Wages per Year by the average number of working days in a year.		
Value of statistical life (VSL)	In order to capture the value of deaths associated with the outbreak, a VSL estimate is calculated for optional inclusion in the analysis. To avoid double-counting, the estimate including the VSL should not also be reported with the YLL component of the DALYs (see Supplemental Data S4). The monetary value of a statistical life that is used in this model is taken from a 2009 report by the Canadian Policy Research Initiative on the appropriate valuation of mortality in policy analysis (Chestnut and De Civita, 2009). The report provides a low, most likely, and high VSL estimate, based on a comprehensive literature review of studies calculating VSL figures using revealed or stated preference willingness to pay (WTP) approaches. These estimates are arranged in a PERT distribution. The product of this PERT distribution and the number of deaths reported in the outbreak (24) provides the total VSL estimate. This analysis assigns the same VSL to each case, regardless of age or underlying condition. The VSL estimates are reported in $2007 CAD, and so are adjusted to 2008 prices.	PERT	Low, most likely, high values $3,618,750.00, $6,720,535.71, $9,822,321.43

SUPPLEMENTARY TABLE S1.2.1. PRODUCTIVITY LOSSES AND DATA SOURCES

Variable or parameter	*Source(s)*	*Value*
Weekend days	As weekends account for 28.27% of a week, the number of weekend days is calculated by multiplying the total duration of illness by 28.27% for each individual in the working age group. This value is then subtracted from each individual's estimated total duration of illness to estimate the total number of days of paid employment that individual might have missed as a result of illness (referred to as sick leave).	Duration of illness × 28.27%
Labor force participation rate	The Canadian labor force participation rate in 2008 for ages 15–64 (both genders) is derived from Statistics Canada (CANSIM Table 282-0002) (Statistics Canada, 2013c)	78.5%
Employment rate	From Statistics Canada (CANSIM Table 109-5324) (Statistics Canada, 2013a), the unemployment rate in Canada in 2008 was 6.1%; therefore, 93.9% of the labor force was employed.	93.9%
Participation rate	The product of the ''Labor Force Participation Rate'' and the ''Employment Rate.''	73.7%
Wages per year	Wage data were collected from the 2006 Census (Statistics Canada, 2011). The mean and standard deviation of income across Canada are calculated based on the data provided for the census sample. The distribution is truncated with a minimum value, representing the minimum daily wage in 2008 ($8.75/hour, multiplied by the average number of hours in a work day, 7.5, multiplied by the number of workdays in a year).	$16,471.875 (min), $32,585.1585 (mean), $27,136.62954 (standard deviation)
Wages per day	Calculated by dividing the estimated wages per year by the average number of working days in a year (52*5–9 statutory holidays = 251 working days).	
Total productivity losses	The product of Adjusted Sick Leave (an estimate of the likely number of days of lost productivity as a result of illness) and Wages per Day.	

Direct non-healthcare costs (DNHC)

Costs considered in this category include travel costs incurred by patients. Consistent with several other cost-of-illness studies (van den Brandhof *et al*., 2004; Kemmeren *et al*., 2006), it is assumed that patients required no additional travel to obtain prescribed medicines (i.e., that medicine was purchased on the way home from a GP visit, and that all medicines for hospitalized patients were administered in the hospital). No information about the type of transportation used is available, so it is assumed that all patients traveled by car. As some cases originated in long-term care facilities, it is possible that they did not travel to see a doctor; in this case, the travel cost figures may be overestimated. Other transportation costs, such as parking fees, are not considered and likely have a negligible impact on direct non-healthcare costs (van den Brandhof *et al*., 2004). All transportation costs are doubled, representing a round trip.

Formally, direct non-healthcare costs are estimated according to the formula:

$$\text{Direct Non-Healthcare Costs} = \Sigma_l\{\Sigma_j(r_j \times q_j \times rc_j)\}$$

Where r is the number of cases requiring a particular service, q is the required units of the non-healthcare service per case, and rc is the unit cost of the non-healthcare service, summed across all health outcomes l and all non-healthcare services j (Supplementary Table S1.3).

SUPPLEMENTARY TABLE S1.3. DIRECT NON-HEALTHCARE COSTS

Model input	*Data source(s)*	*Distribution*	*Parameters*
Number of cases traveling to a hospital	It was assumed that all cases in which listeriosis was a contributing cause of hospitalization traveled to a hospital. These travel fees are included in the outbreak costs. For cases in the hospital but listeriosis was not a contributing cause, and travel fees were not counted as costs.	Constant	47
Number of cases traveling to a GP clinic	It was assumed that cases with a total duration of illness ≤1 day, as well as those with mild clinical presentations, would travel to see a general physician (GP).	Constant	4
Number of trips to a hospital	It was assumed that all cases traveling to a hospital made only one round trip associated with their illness.	Constant	1
Number of trips to a GP clinic	For cases with a total duration of illness ≤1 day, it was assumed that one trip to a GP clinic was made. For cases with mild clinical presentations, the number of trips to a GP clinic is modeled in a PERT distribution.	PERT	Low, most likely, high values (1, 5, 7)
Transportation distance to a hospital	Average distance to a hospital in Canada is drawn from the Canadian Institute of Health Information (CIHI) study *Geographic Distribution of Physicians in Canada: Beyond How Many and Where* (2005) (Pong and Pitblado, 2005). The average distance to a hospital with long-term care is selected as the distance traveled for hospitalized cases (16.3 km).	Constant	16.3 km
Transportation distance to a GP office	Average distance to a family health clinic in Canada is drawn from the CIHI study *Geographic Distribution of Physicians in Canada: Beyond How Many and Where* (2005) (Pong and Pitblado, 2005).	Constant	3.5 km
Transportation cost per kilometer	Average cost per kilometer is drawn from the Canada Revenue Agency "Automobile Allowance Rates" for 2008 (Canada Revenue Agency, 2014).	Constant	$0.52
Notes	Due to the small impact of these costs on the overall cost of illness analysis, no uncertainty measures are considered for these estimates.		

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Supplementary Data S2: Federal Outbreak Response Costs

Federal outbreak response costs include expenditures by Health Canada, the Public Health Agency of Canada (PHAC), and the Canadian Food Inspection Agency (CFIA), and include laboratory testing performed at the National Microbiology Laboratory (PHAC) and food sample testing performed by Health Canada (Supplementary Table S2.1; Supplementary Data are available online at www.liebertpub.com/fpd). For PHAC personnel costs there are two main time periods of interest: the time during the peak of the outbreak investigation (July 27–September 6, 2008, 30 working days), and the post-outbreak period (September 7–October 25, 2008, 35 working days), hereafter referred to as Time 1 and Time 2. The number of hours spent on outbreak activities in each period and the associated costs are calculated separately, as are the number of hours and cost associated with overtime. Limited information is available for certain agencies and departments as detailed in Supplementary Table S2.2.

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SUPPLEMENTARY TABLE S2.1. FEDERAL OUTBREAK RESPONSE COSTS MODEL INPUTS

Model input	*Data source(s)*	*Distribution*	*Parameters*
Total cost to Health Canada	The estimated cost to Health Canada was reported as $224,175.00. To account for uncertainty in this estimate, a PERT distribution was constructed. The most likely value was assumed to be the estimate reported by Health Canada ($224,175.00), and the minimum and maximum estimate are ±10% of this figure.	PERT	Low, most likely, high values $Value–10%, $Value, $Value +10%
Public Health Agency of Canada (PHAC): Cost to Outbreak Management Division (OMD) and Enteric Surveillance and Population Studies Division (ESPS)	A retrospective survey of OMD and ESPS staff involved in the outbreak response was administered in Fall 2011–Spring 2012. Respondents estimated the percentage of regular working hours that were devoted to listeriosis outbreak activities during each week in Time 1 and Time 2. The weekly ranges of percentages were transformed into uniform distributions to account for uncertainty, and then multiplied by the number of hours in a typical work week (37.5). The percentage of total working hours spent on the outbreak investigation for Time 1 and Time 2 were calculated. One individual was unable to complete the survey, and the average proportions for each time period were applied to the total number of working hours in Time 1 and Time 2 as a proxy for this individual's time during the outbreak investigation. The official position and salary level of each individual at the time of the outbreak was recorded, as well as the associated annual salary figure (in 2008). These values were converted to hourly wages. All of the overtime recorded by OMD personnel working on the outbreak in August and September of 2008 was attributed to the investigation. Overtime in August was counted as overtime in Time 1 and overtime in September was counted as overtime in Time 2. Depending on the overtime shift, pay was at the rate of 1.5 or 2 times the regular salary. These values were applied accordingly and then totaled to estimate the total overtime costs for OMD.	Uniform (Time devoted to outbreak)	Varies by individual and by week
PHAC: Cost to National Microbiology Laboratory (NML)	Time periods of interest for NML are distinct from the other PHAC departments involved in the outbreak and reflect specimen testing timelines. They are divided into the pre-outbreak investigation (July 10–August 12, 24 working days), peak-outbreak investigation (August 13–October 14, 45 working days), and post-outbreak investigation (October 15–November 7, 18 working days) periods. The percentage of time in each period spent on outbreak-related activities, as well as the daily salary of each individual, were reported by NML. Percentages were applied to the number of hours in a standard work week to determine the total hours devoted to the outbreak investigation. The dollar value of overtime related to the outbreak was provided for each individual. Based on the associated individual daily wages, hourly wages were calculated. Applying a standard 1.5 multiplier to regular hourly wages, the overtime wage was calculated for each person. The total monetary value of overtime for each individual was divided by these overtime wages to estimate the number of overtime hours spent on the outbreak for NML.		

(*continued*)

SUPPLEMENTARY TABLE S2.1. (CONTINUED)

Model input	*Data source(s)*	*Distribution*	*Parameters*
PHAC: Cost to Centre for Emergency Preparedness and Response (CEPR)	CEPR provided a list of individuals who worked on the outbreak investigation, and the estimated number of hours spent for most people ($n=11$). For individuals with missing estimates ($n=5$), the average amount of time spent by an individual at CEPR was used (60 h). For those where time was not indicated as Time 1 or 2, the proportion of total hours by Times 1 and 2 reported by OMD (Time 1 = 61.44%, Time 2 = 38.56%) were applied to estimates from CEPR to generate the breakdown by time period. To account for uncertainty in the number of hours reported for each individual, estimates for Time 1 and 2 were described in a PERT distribution ±10%. Salary information was based on the assumed average position of an employee at CEPR (PM05). See Supplementary Data S2, Table S2.2 for additional information about salaries. No overtime estimates were available.	PERT (Hours) Discrete uniform (Salary)	Low, most likely, high values Hours–10%, Hours, Hours +10% $70,032, $72,694, $75,715
PHAC: Cost to Communications (Comms)	PHAC Comms estimated the number of Full Time Equivalents (FTE) involved in the outbreak in Time 1 and Time 2. To estimate the number of hours that these individuals devoted to the outbreak specifically, the number of total working hours in each time period (30 days*7.5 h for Time 1; 35 days*7.5 h for Time 2) was calculated, and then the percentage of total working hours spent on outbreak-related activities reported by OMD in each time period were applied. To account for uncertainty in these proportions, a PERT distribution was built ±10 percentage points. Salary estimates were based on the assumed average salary of an employee at PHAC Comms (IS05). Salary ''Steps'' were combined in a discrete uniform distribution, then converted to hourly amounts (see Supplementary Data S2, Table S2.2). No overtime estimates were available.	PERT (Time Devoted to Outbreak) Discrete Uniform (Salary)	Low, most likely, high values OMD Proportion–0.1, OMD Proportion, OMD Proportion +0.1 $78,007, $80,972, $84,154
PHAC: Cost to Director General's Office (DGO) of CFEZID	The DGO provided estimates of the number of executives and administrative support personnel occupied by the outbreak investigation. It was estimated that the single executive position (EX03) at a minimum spent the same amount of time as the average OMD employee and that the three administrative positions (AS03) each spent half the amount of time as the executive position occupied by the outbreak response. The proportion of time spent on outbreak-related activities by OMD (combined Time 1 and 2) was used to construct a PERT distribution with the minimum equal to the proportion of OMD time, the most likely of OMD time +0.1 and a maximum of OMD time +0.2. See Supplementary Data S2, Table S2.2 for data sources for salaries. Both annual salary distributions are converted to hourly wages. No overtime estimates were available for DGO.	PERT (Time Devoted to Outbreak— EX) PERT (Time Devoted to Outbreak— AS) Uniform (Salary— EX) Discrete Uniform (Salary - AS)	Low, most likely, high values OMD Proportion, OMD Propotion +0.1, OMD Proportion +0.2 (OMD Proportion)/2, (OMD Proportion)/2 + 0.05, (OMD Proportion)/2 + 0.1 Min, max $123,000 $147,000 $53,702, $55,743, $57,861
Laboratory costs	See Supplementary Data S2, Table S2.2.	Constant	$25,773.70
Total cost to PHAC	The cost of all personnel hours and additional laboratory expenses are summed to arrive at an estimate for the total cost to PHAC. See Supplementary Data S2, Table S2.2 for more detail.		
Total cost to Canadian Food Inspection Agency (CFIA)	No estimate for the cost of the outbreak to the CFIA was available. It is assumed the costs to CFIA would be equal or greater to that of PHAC. To account for uncertainty, a PERT distribution is created where the minimum is the total cost to PHAC, the most likely is 1.5 times the total PHAC cost, and the maximum is 2 times the total PHAC cost.	PERT	Low, most likely, high values ($PHAC, $PHAC*1.5 $PHAC*2)

SUPPLEMENTARY TABLE S2.2. DATA SOURCES FOR FEDERAL OUTBREAK RESPONSE COSTS

Variable or parameter	*Source(s)*
Salary levels for Centre for Emergency Preparedness and Response (CEPR), Communications, and Director General's Office (DGO)	Salary figures for Public Health Agency of Canada (PHAC) divisions that did not report specific salary figures for individuals were obtained from the Treasury Board of Canada's Archived Collective Agreements 2009–2011, which includes 2008 salary data (Treasury Board of Canada, 2013). Salaries are listed in different ''steps'' that an individual can earn; to account for uncertainty regarding what ''step'' an each individual earned at the time of the outbreak, these steps were combined in a discrete uniform distribution. The exception is the executive position (EX03), which is governed by another agreement. For this position the most relevant salary information dates from 2009 and includes a minimum to maximum allowable salary; these were arranged in a uniform distribution, and adjusted to 2008 prices using the Canadian Consumer Price Index. Values vary by government position.
Salary per hour	The yearly salary values described above were divided by the number of working days in a year (251) and the number of hours in a typical working day (7.5) to obtain salary per-hour estimates.
Laboratory costs	In addition to personnel costs, PHAC reported laboratory costs associated with the outbreak, including Roche sequencing runs, Sanger sequencing, PCR, fosmid library prep, and other consumables. These costs are added to the personnel costs reported by PHAC to arrive at a total cost estimate for PHAC. It is assumed that no uncertainty exists regarding these costs.
PHAC: Total hours	The estimated number of personnel hours devoted to the outbreak in Time 1 and Time 2 are totaled individually to provide total estimates for each time period. These figures were added together and combined with the number of hours spent in each period of interest to National Microbiology Laboratory (NML) (not included in the Time 1 and Time 2 estimates), as well as the total number of overtime hours reported to arrive at an estimate of the total number of hours spent by PHAC employees on the outbreak investigation.
Total cost to PHAC	The cost of personnel hours (calculated as the number of hours multiplied by the hourly salary for each individuals) were totaled across all divisions for each time period (NML estimates were not included in the cost of Time 1 or Time 2). The estimated human resources costs of Time 1 and Time 2 were added to the total cost of NML personnel. Overtime costs and laboratory costs were also added to the final figure for the total cost of the outbreak to PHAC.

Supplementary Data S3: Implicated Meat-Processing Facility (IMP) Costs

Minimal information is available regarding costs to the IMP associated with this outbreak, and thus there is a high level of uncertainty surrounding the estimated costs.

References

CBC News. $27M settlement reached in Maple Leaf listeriosis suits. 2009; 2013. Available at: http://www.cbc.ca/news/27m-settlement-reached-in-maple-leaf-listeriosis-suits-1.810045, accessed October 16, 2013.

SUPPLEMENTARY TABLE S3.1. IMPLICATED MEAT-PROCESSING FACILITY (IMP) COSTS

Model input	*Data source(s)*	*Distribution*	*Parameters*
Revised cost estimate for the IMP, reported by Toronto Star	The Toronto Star reported that a company spokesperson estimated that the direct costs of the outbreak for the IMP ranged from $25 to $30 million (Flavelle, 2008).	Range	$25–$30 million
Cost Estimate from IMP, reported by R. Huffman	R. Huffman, a contact at the IMP, reported that the cost to the company was $100 million. This figure reportedly includes direct, indirect, and legal costs.	Constant	$100 million
Legal settlement	The CBC reported a $27 million legal settlement between the IMP and the individuals affected by the outbreak (CBC News, 2009).	Constant	$27 million
Cost distribution	Due to the high level of uncertainty surrounding these estimates, the cost figures were arranged in a uniform distribution. The minimum cost was assumed to include the known legal settlement, plus some additional direct cost to the company (determined as the average of the direct costs reported by the Toronto Star, $27.5 million). The estimate reported by Mr. Huffman ($100 million) was used as the maximum cost estimate, as this estimate reportedly accounts for direct, indirect, and legal fees.	Uniform	Min, max ($54.5 million, $100 million)

Flavelle D. Maple Leaf Foods profits sliced by *Listeria* outbreak. Toronto Star 2008; 2013. Available at: http://www.thestar.com/business/2008/10/30/maple_leaf_foods_profits_sliced_by_listeria_outbreak.html, accessed October 11, 2013.

Supplementary Data S4: Disability-Adjusted Life Years (DALYs)

DALYs

Since its use as a measure of the burden of illness in the World Health Organization's Global Burden of Disease study (Murray and Lopez, 1997), the disability-adjusted life year (DALY) has gained increasing recognition in studies of the individual and social burden of foodborne illness. The DALY measure combines both morbidity and mortality into one indicator of disease burden, and it avoids the myriad of ethical issues that surround the process of placing a monetary value on life lost, lost leisure time, or on pain and suffering associated with disease. DALYs are calculated as the sum of Years of Life Lost due to premature mortality following illness, and Years Lost due to Disability, which is weighted by a disability factor between 0 and 1 indicating the severity of the disease or condition (World Health Organization, 2013). One DALY can be conceptualized as 1 lost year of healthy life, and when totaled up over all cases and disease outcomes it provides a reasonable measure of the quality-adjusted loss of healthy life due to the illness. Since the publication of the Global Burden of Disease study in 1996, disease burden studies around the world have utilized DALYs to calculate the loss due to mortality and morbidity of various diseases (van den Brandhof *et al*., 2004; Kemmeren *et al*., 2006; Cressey and Lake, 2008; Havelaar *et al*., 2012).

Formally, the number of DALYs associated with the listeriosis outbreak (Fig. S4.1) can be calculated as:

$$\mathrm{DALY_S} = \Sigma YLL + YLD$$

where $YLL = \Sigma_l (d\mathrm{l} \times e\mathrm{l})$

Years of Life Lost equals the sum of all deaths (d) due to each health outcome (l) multiplied by the expected years of life remaining at the age of death (e).

And $YLD = \Sigma_l (n\mathrm{l} \times t\mathrm{l} \times w\mathrm{l})$

Years Lost due to Disability equals the sum across all cases (n) and all health outcomes (l), of the duration of illness (t) multiplied by the applicable disability weight (w) (Supplementary Table S4.1).

Supplementary Tables S4.2 and S4.3 describe in more depth the inputs and data sources used to construct the estimates of Years of Life Lost and Years of Life Lived with Disability that are totaled up to generate Disability Adjusted Life Years (DALYs). In particular, the values for life expectancy used to calculate Years of Life Lost, and the disability weights used in the calculation of Years of Life Lived with Disability are described. It is necessary to apply disability weights to each disease state or outcome situation that can occur, and disability weights for each of the outcomes reported in the 2008 listeriosis outbreak are obtained from the international literature.

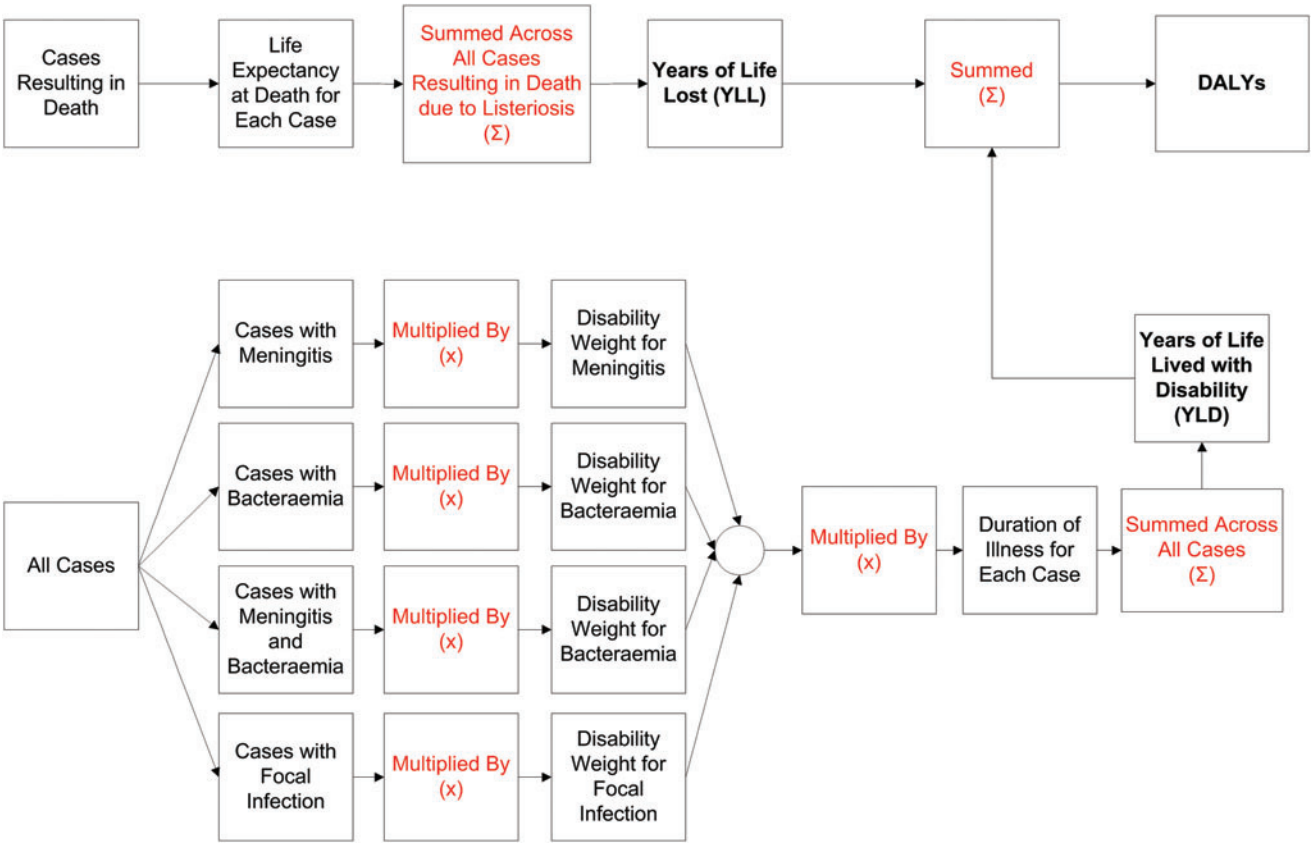
Discounted DALYs

Based on the assumption that present years lived are more highly valued than potential future years lived, it is common

SUPPLEMENTARY TABLE S4.1. DALY MODEL AND METHODOLOGY

Model input	*Data source(s)*	*Distribution*	*Parameters*
DALYs			
Life expectancy at death	Estimated as the Reduced Life Expectancy value by age and gender for each case resulting in death. See Supplementary Data S4 Table S4.2 for more detail.	Constant	Varies by age and gender
Cases with different clinical presentations	The number of cases with meningitis, sepsis/bacteremia, meningitis and bacteremia, and focal infections is described in the national outbreak dataset (Currie *et al*., 2015).	Constant	Varies by clinical presentation
Duration of illness	Duration of illness for each case was estimated for the Direct Healthcare Costs. Since durations are estimated in terms of the number of days of illness, these values are divided by 365 so that the measure reflects the number of years of illness.		
Disability weights	The disability weights applied to this model are derived from Kemmeren *et al.* (Kemmeren *et al*., 2006), based on a previous Dutch study of the disability weights for foodborne pathogens (Melse and Kramer, 1998). No Canada-specific estimates are available, so these weights are used as a proxy for similar Canadian values. See Supplementary Data S4 Table S4.3 for more detail.	Constant	

DALY, disability-adjusted life year.



SUPPLEMENTARY FIG. S4.1. Visualization of Disability-Adjusted Life Years (DALYs) methodology for this outbreak.

SUPPLEMENTARY TABLE S4.2. YEARS OF LIFE LOST MODEL AND METHODOLOGY

Variable or parameter	*Source(s) and justification*	*Value*
Standard life expectancy	Estimated years of life remaining at each age (0–110) by sex for Canada from 2007 to 2009 derived from Statistics Canada's *Life Tables: Canada, Provinces and Territories* report (Statistics Canada, 2012). Standard life expectancy indicates the country-specific number of expected years of life remaining at each age, and as this value is never zero, all deaths represent the loss of expected years of life. This is the measure of life expectancy recommended by Murray (Murray, 1994).	Varies by age and gender
Reduced life expectancy	The life expectancy of individuals with serious underlying medical conditions has been reduced by half to reflect a lower life expectancy for the seriously ill. Kemmeren *et al*. (2006) use reduced life expectancy values for all non-pregnancy-related cases of listeriosis (Kemmeren *et al*., 2006). Other studies have made similar assumptions for acquired listeriosis (Cressey and Lake, 2008; Haagsma *et al*., 2009; Havelaar *et al*., 2012).	SLE*(0.5) Varies by age and gender
Life expectancy at death	A reduced life expectancy value was applied to all deceased cases in this study. As none of the cases in this outbreak were pregnancy-related, it is likely that those individuals who acquired a serious listeriosis infection—particularly one resulting in death—had a severe underlying condition that reduced the individual's life expectancy. This is supported by the data collected in the outbreak report, which indicated that for cases where information about prior health status was reported ($n = 11$), all had underlying medical conditions.	RLE Varies by age and gender
Years of life lost	Years of life lost is calculated as the sum of the life expectancy at death across all deaths related to the outbreak.	Constant no. from model

RLE, reduced life expectancy; SLE, standard life expectancy.

SUPPLEMENTARY TABLE S4.3. DISABILITY WEIGHTS AND SOURCES

Clinical presentation	*Disability weight*	*Source(s)*
Meningitis	0.32	Disability weight for ''Meningitis'' used in Kemmeren *et al.* (Kemmeren *et al.*, 2006), derived from Melse and Kramer (Melse and Kramer, 1998)
Bacteremia	0.93	Disability weight for ''Sepsis'' used in Kemmeren *et al.* (Kemmeren *et al.*, 2006), derived from Melse and Kramer (Melse and Kramer, 1998)
Meningitis + bacteremia	0.93	For cases with both meningitis and bacteremia, the more severe weight (0.93) is used
Focal infection	0.11	Disability weight for ''Listeriosis—Severe symptoms (not further specified)'' in Kemmeren *et al.* (Kemmeren *et al.*, 2006), derived from the disease description ''large difficulties or not able to ADL'' (activities of daily living) in Melse and Kramer (Melse and Kramer, 1998)

practice in economic analyses to discount future benefits and costs into their current value (Murray, 1994). However, as this practice is controversial (Murray, 1994; Anand and Hanson, 1997), these estimates are primarily calculated for comparison purposes with other burden-of-illness studies (Kemmeren *et al.*, 2006; Cressey and Lake, 2008; Haagsma *et al.*, 2009).

The formula for discounted years of life lost that is applied in this case is: $YLL(5\%) = \frac{N}{r}(1 - e^{-rL})$, where L is the life expectancy, r is the discount rate (5%), and N is the number of deaths. The formula for years of life lived with disability that is applied in this case is: $YLD(5\%) = \frac{I*DW*(1-e^{-rt})}{r}$, where I is the incidence or number of cases, DW is the disability weight, r is the discount rate (5%), and t is the duration of illness (Mathers *et al.*, 2001; Pruss-Ustun *et al.*, 2003). Discounted estimates are sensitive to the selection of the discount rate. Larg and Moss (2011) recommend a discount rate between 3% and 5% for cost of illness studies (Larg and Moss, 2011). The discount rate for this study is 5%, based on the rate used in the *Economic Burden of Illness in Canada* (1998) report published by the Public Health Agency of Canada (Policy Research Division *et al.*, 2002).

Supplementary Table S4.4 provides a summary of the estimated DALYs attributed to the listeriosis outbreak. Both the undiscounted and discounted estimates are provided for comparison purposes.

SUPPLEMENTARY TABLE S4.4. DALY ESTIMATES, UNDISCOUNTED AND DISCOUNTED (5%)

	Mean	*5%*	*95%*
Undiscounted			
Years of life lost	139	139	139
Years of life lived with disability	3	2	4
DALYs	142	142	143
Discounted			
Years of life lost	112	112	112
Years of life lived with disability	3	2	4
DALYs	115	114	116

DALY, disability-adjusted life year.

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