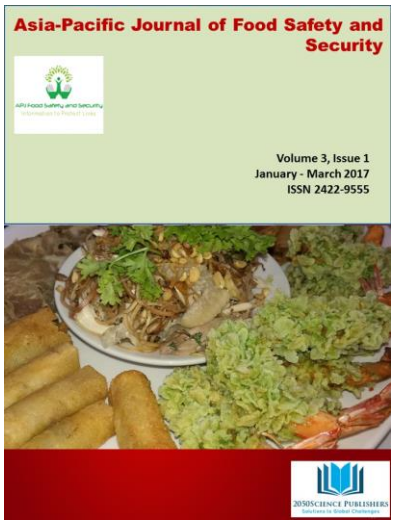
Asia-Pacific Journal of Food Safety and Security
OPEN ACCESS
ISSN 2422-9555
Volume 3, Issue 1 (http://apjfss.wix.com/apjfss)
2050SCIENCE PUBLISHERS
Solutions to Global Challenges
January – March 2017

Theme: *Food Safety*

Research Paper



Estimates for the burden and costs of foodborne diarrhoeal illness in Indonesia

Stephen L. W. On[1] and Winiati P. Rahayu[2]

[1] Department of Wine, Food and Molecular Biosciences, Faculty of Agriculture and Life Sciences, Lincoln University, PO Box 85084, Lincoln, New Zealand

[2] Department of Food Science and Technology and SEAFAST Center, Bogor Agricultural University, Bogor-Indonesia

***Corresponding author's email address:**
Stephen.on@lincoln.ac.nz

Received: January 6, 2017/ Revised: February 23, 2017/Accepted: February 24, 2017/ Published online: February 27, 2017

Academic Editors: William Riley and Malik A. Hussain

To cite this article:
On, S.L.W. and Rahayu, W.P. (2017). Estimates for the burden and costs of foodborne diarrhoeal illness in Indonesia. *Asia-Pacific Journal of Food Safety and Security,* 3(1), 3-16.

Highlights

- Estimates for the burden of foodborne diarrhoeal disease in Indonesia are presented.
- Estimates for the costs of foodborne diarrhoeal disease in Indonesia are presented.
- Foodborne diarrhoeal illness is estimated to be a significant public health and economic burden in Indonesia.

About Authors

Stephen On (PhD) is an Associate Professor of Food Microbiology at Lincoln University in New Zealand. He has previously worked in Government research organisations in New Zealand, Denmark and the UK and is a well-published researcher in food- and waterborne pathogens with a current H-index of 43. He is an Executive Committee member of the NZ Microbiological Society and Chairman of the ICSP (International) sub-committee on the taxonomy of *Campylobacter* and related bacteria. He has contributed to various expert advisory groups at the request of the World Health Organisation, Ministry for Primary Industries and the World Bank-sponsored Global Food Safety Partnership.
Winiati Rahayu (PhD) is a Professor in Food and Nutrition of Science and Technology at Bogor Agricultural University in Indonesia. Her professional education has included periods in both Indonesia and the USA (Purdue University) and she has held an extensive range of key appointments at National and International levels. These have included; Executive Secretary of the Indonesian Association of Food Technologies; Secretary General of the Indonesian Food Intelligence Network, National Expert of Wageningen International and Technical expert and consultant to the WHO in risk assessment activities. She is a long-standing member of the Advisory board, and Senior researcher, on the South-East Asia for Food and Agricultural Science and Technology (SEAFAST) Centre.

Abstract

Estimates for the burden (number of cases) and cost of diarrhoeal foodborne illness (FBI) per year in Indonesia were calculated. Distinct data sources and models (derived from the World Health Organisation, and Indonesian sources) were used to cross-validate results from each analysis. For all cases, estimates of the burdens and costs of the foodborne illnesses were broadly of the same magnitude. Total annual estimates of diarrhoeal FBI cases in Indonesia ranged from 10,189,312 to 22,476,423, with costs estimated as $4,763,051,067–16,752,046,500 USD. Estimates concur with similar studies in other countries that indicate the huge burden and cost of foodborne illness worldwide, emphasising the need for appropriate countermeasures to reduce this burden.

Keywords: foodborne illness, foodborne pathogens, cost estimates, burden of disease estimates, Indonesia

1. Introduction

Foodborne illness (FBI) is widely and rightly recognised as a major burden to public health worldwide (Havelaar et al. 2015; WHO 2015). Estimating the burden of disease caused by foodborne hazards is a complex and difficult task. There is a wide range of microbial, parasitic, and chemical causes of FBI (WHO, 2008a, b, 2015; see later), with exposure pathways to humans that may not be exclusively through contaminated foods: environmental, animal or person-to-person contact, for example. Attribution of the foodborne component of such illnesses is not trivial (Hald et al. 2016). Estimates should also account for the significant level of underreporting of cases to the public health system. In brief, not everyone that acquires infection will progress to a diagnosis and/or record in the public health system. Estimates of the scale of underreporting are seldom trivial, but marked variance between ranges observed in published studies have been observed (eg. Wheeler et al. 1999; Persuad et al. 2013). Since estimating the burden of FBI is difficult, it is a similarly taxing task to evaluate the associated costs of illness (COI) on a national basis. Nonetheless, with the increasing body of evidence demonstrating the significant incidence of FBI worldwide, with commensurate COI associated with this burden, there has been significant interest in establishing more accurate evaluations of both metrics, to help guide measures that are appropriate for improvements to both public health and public finances. Previous undertakings to estimate the cost of FBI in Indonesia involved development and application of a model that was applied to outbreak cases in 2013, in which COI was estimated as $78,001.095

USD (Rahayu et al. 2016). However, since outbreaks of disease only represent a fraction of the whole burden of disease (WHO 2008b), this value is likely to be a significant underestimate of COI for foodborne illness in Indonesia.

In this paper, a number of different data sources and approaches are used to estimate the burden of FBI and corresponding COI, for the whole of Indonesia.

2. Materials and Methods

2.1. **Core data sources.** A variety of data sources were utilised in the analyses described here:

a) Rahayu et al. (2016). Indonesian model for estimation of economic losses due to foodborne outbreaks. Havelaar et al. (2015). World Health Organisation (WHO)-based global and regional estimates of the burden of foodborne diarrhoeal disease in 2010.

b) Agtini *et* al. 2005. A two-year study of the burden of diarrhoea, shigellosis, and cholera in North Jakarta, Indonesia: the only such study in the country identified from published academic literature.

c) Hald et al. (2016). Estimates by the WHO of the relative contributions of food to the burden of disease due to selected foodborne hazards, used for attributing Indonesian diarrhoeal cases (Agtini *et al.* 2005) to those of foodborne origin.

d) Centers for Disease Control (CDC) website (per capita income estimates for Indonesia ($10,250) (www.cdc.gov/globalhealth/countries/Indonesia).

e) Population census data from 2013 publicly available for each of the South-East Asian subgroup B (SEAR-B) countries as defined by the WHO in their global estimates of foodborne illness (Havelaar et al. 2015; WHO 2015). Figures used (millions) were: Indonesia, 249.9; Thailand, 67.01; and Sri Lanka, 20.48. For Jakarta, the population in 2010 was found to be 9.608 million.

2.2. **Underreporting estimates.** To evaluate the range and degree to which diarrhoeal cases may be underreported for incorporation into the Indonesian models, studies from British Columbia, Grenada, Guyana, Jamaica, New Zealand, Ontario and the United Kingdom were examined (Wheeler et al. 1999; Majowicz et al. 2005; MacDougall et al. 2008; Lake et al. 2009; Tam et al. 2012; Glasgow et al. 2013; Persuad et al. 2013; Fletcher et al. 2013).

2.3. **Estimates for the burden and cost of FBI in Indonesia.** Three distinct approaches were used to calculate five sets of revised estimates of the cost of FBI in Indonesia.

1. *WHO DALY estimates*. The WHO-commissioned global burden of illness study provided detailed estimates of the burden of foodborne disease caused from 31 key microbial, parasitic and chemical hazards in each of 14 regions of the world. These estimates incorporate consideration of underreporting (WHO 2015). Indonesia was included in the South-East Asia Region B (SEAR-B), alongside Thailand and Sri Lanka. The scientific methodologies, including data collection, source attribution and DALY calculation have been robustly developed and published (Devleesschauewer et al. 2015; Hald et al. 2016; Havelaar et al. 2015; WHO 2008a 2015). To facilitate comparison with available Indonesian data (Agtini et al. 2005), only results from 26 bacterial, viral and parasitic agents included in the WHO-commissioned study were used. The diarrheogenic nature of the agents included in the present analysis was checked independently before inclusion; microorganisms able to cause both invasive disease and diarrhoea were included in the current analysis, given their potential for the latter. The Indonesian DALY fraction of the SEAR-B analysis (74.06858%) was calculated using 2013 population data for all three countries. Since one DALY equates to one year of productive life lost, the cost of FBI in this model was calculated by multiplying DALY estimates for Indonesia (1.711815 million) with per capita income estimates for Indonesia from the CDC ($10, 250; as above).

2. *Replacement of outbreak data with WHO FBI case estimates*. The estimated number of foodborne outbreak cases used in the Indonesian Rahayu ***et al.*** (2016) model (169,000) were replaced with those from the WHO estimates of diarrheoal FBI in the SEAR-B region adjusted for the Indonesian population only (16,504,559 cases: i.e. 74.06858% of the SEAR-B incidence of 23,094,487).

3. North Jakarta diarrheoal data reworking. A two-year study on the incidence of diarrhoea in North Jakarta (Agtini *et al.* 2005) listed cases of diarrhoea with *Vibrio cholera, Shigella* spp., and unspecified causes. These data were re-examined to attribute possible causes of FBI in the unspecified fraction by cross-referencing proportions of cases caused by each of 26 foodborne diarrheogenic hazards (viruses, bacteria, parasites) for the SEAR-B region as estimated by Havelaar et al. (2015); and attributing the fraction that may be due to consumption to contaminated food by cross-referencing estimates of

Hald et al. (2016). Since *V. parahaemolyticus* was not included in the Hald et al. (2016) estimates, the attribution fraction of 99% to food consumption was derived from a risk profile for this organism produced by the Food and Agriculture Organisation (FAO 2011). Chemical foodborne hazards included in the WHO study were not considered since typical sequelae do not include diarrhoea (Havelaar et al. 2015). Estimated cases of FBI in North Jakarta were then modelled according to available census figures for Jakarta (9.608 M in 2010) and Indonesia (249.9 M in 2013) to represent the total population of Indonesia. This represented a multiplication factor of 26. An underreporting rate of 136 (Model 3, Table 2) per case reported was used, which was the lowest estimate found in comparable country studies of FBI (Wheeler et al. 1999) (Table 1). Underreporting rates of 200 (Model 4, Table 2) and 300 (Model 5, Table 2) per case were also included for comparison since both values fell within the median range of known underreporting values (Table 1).

3. Results

3.1. Estimates of the underreporting level of diarrhoeal cases in other countries

Results from a number of international studies are given in Table 1 and indicate that underreporting of diarrhoeal cases can vary from 136 (Wheeler et al. 1999) to 2881 (Persuad et al. 2013).

Table 1. Estimates of the underreporting level of diarrhoeal cases and their sources.

Country	Underreporting factor	Source
British Columbia	347	MacDougall et al. 2008
Grenada	316	Glasgow et al. 2013
Guyana	2881	Persuad et al. 2013
Jamaica	383	Fletcher et al. 2013
New Zealand	222	Lake et al. 2009
Ontario	285	Majowicz et al. 2005
United Kingdom	136	Wheeler et al. 1999
United Kingdom	147	Tam et al. 2012

3.2. Estimates of annual burden of foodborne diarrhoeal illness in Indonesia

Table 2 displays our estimates of foodborne illness in Indonesia caused by each of 19 potentially diarrhoeagenic pathogens, as derived from the results of Agtini et al. (2005), calculated as described in section 2.3. Total annual estimates of diarrhoeal FBI cases ranged from 10, 189,312 to 22, 476, 423.

Table 2. Estimates of annual burden of foodborne diarrhoeal illness in Indonesia, based on North Jakartan (Agtini et al. 2005) data and WHO- or FAO/WHO derived organismal attribution values (FAO/WHO 2011; Hald et al. 2016). See text for details.

Organism	% of diarrhoeal cases (WHO 2011)	Estimated no. of diarrhoeal cases (Indonesia)	% Attribution to FBI (median value, WHO 2011)	Estimated no. of diarrhoeal FBI cases (Indonesia): no underreporting applied	Underreporting factor 136 (Model 3)	Underreporting factor 200 (Model 4)	Underreporting factor 300 (Model 5)
Campylobacter	0.18635	35318.35645	0.57	20131.46318	2737878.992	547575798.4	1.64273E+11
non-typhoidal *Salmonella*	0.1448	27443.5096	0.58	15917.23557	2164744.037	432948807.4	1.29885E+11
STEC	0.00319	604.59113	0.41	247.8823633	33712.00141	6742400.282	2022720085
Brucella	0.00038	72.02026	0.51	36.7303326	4995.325234	999065.0467	299719514
Enteropathogenic *E. coli*	0.08403	15925.95381	0.29	4618.526605	628119.6183	125623923.7	37687177096
Enterotoxigenic *E. coli*	0.15672	29702.67144	0.38	11287.01515	1535034.06	307006812	92102043601
Cryptosporidium	0.01008	1910.43216	0.1	191.043216	25981.87738	5196375.475	1558912643
Giardia	0.02016	3820.86432	0.13	496.7123616	67552.88118	13510576.24	4053172871
Salmonella Typhi	0.0383	7258.8841	0.43	3121.320163	424499.5422	84899908.43	25469972530
Norovirus	0.10077	19098.63579	0.12	2291.836295	311689.7361	62337947.22	18701384166
Hepatitis A	0.00748	1417.66196	0.34	482.0050664	65552.68903	13110537.81	3933161342
Listeria	0.00002	3.79054	1	3.79054	515.51344	103102.688	30930806.4

Entamoeba histolytica	0.03658	6932.89766	0.26	1802.553392	245147.2613	49029452.25	14708835675
Toxoplasma gondii	0.03001	5687.70527	0.52	2957.60674	402234.5167	80446903.34	24134071002
Mycobacterium bovis	0.00028	53.06756	1	53.06756	7217.18816	1443437.632	433031289.6
Helminths (cestodes, nematodes, trematoda)	0.02377	4505.05679	0.56	2522.831802	343105.1251	68621025.03	20586307508
Shigella	NA	15639	0.36	5630.04	765685.44	153137088	45941126400
Vibrio cholerae	NA	4082	0.36	1469.52	199854.72	39970944	11991283200
V. parahaemolyticus	NA	1677	0.99	1660.23	225791.28	45158256	13547476800
Total				74921.41033	10189311.8	14984282.07	22476423.1

3.3. Estimated cases and associated costs of diarrhoeal FBI in Indonesia based on WHO DALY, WHO-Rahayu modelling and Agtini-Rahayu modelling.

Results from each of the models described above are given in Table 3. The estimated costs of diarrhoeal FBI p.a. were estimated to range between $4,763,051,067–16,752,046,500 USD.

Table 3. Estimated number of cases of FBI in Indonesia per annum and their associated costs according to each of five different models. The original estimates by Rahayu et al. (2016) are included as a reference for comparison. For details of the approaches used, refer to the numberings in the "Revised cost estimates" section.

Model name and number	Estimated number of diarrhoeal FBI cases	Estimated cost of illness (USD)
Rahayu *et al.* 2016 (reference model)	169,000	$78,001,095
WHO-DALY (1)	16,504,559	$16752,046,500
WHO- Rahayu (2)	16,504,559	$7,715,148,860
Agtini- Rahayu (3)	10,189,312	$4,763,051,067
Agtini- Rahayu (4)	14,984283	$7,004,486,863

Agtini- Rahayu (5)	22,476,423	$10,506,730,295

4. Discussion.

4.1. Estimated costs of foodborne illness in Indonesia.

Estimates of the burden of FBI and the corresponding costs are, as described above, complex undertakings in which many factors must be considered. The accuracy of any analysis is naturally dependant on the quality, quantity and accuracy of the data available. However, the scale of the exercise invariably results in a range of necessary assumptions being made to complete the estimates. In a comprehensive study to estimate the global burden of foodborne illness, the authors stated that "our study is subject to several limitations, notably due to uncertainties in the data limitations on burden estimates and attribution estimates" (Havelaar et al. 2015). The commentary and results contained in this report on the Indonesian situation must be viewed in that light.

The present study is believed to be the first to estimate the burden of FBI and associated COI for the whole of Indonesia. Previous studies have examined FBI in North Jakarta (Agtini et al. 2005), at a South East Asian Regional level (Havelaar *et* al. 2015; Hald *et al.* 2016; WHO, 2015), or outbreaks of FBI in Indonesia (Rahayu et al. 2016). The algorithm developed in the latter study was used as the baseline model for nationwide COI estimates presented here, since it incorporated local knowledge. Some caveats to the use of the model should be noted, however, including assumptions for: (a) costings for transportation that may vary from city to city; (b) fatal cases representing a loss of 12 productive years; and (c) mortality cost representing $7 USD. Nonetheless, the use of a very different approach in which the cost burden of FBI for Indonesia represented by Disability Adjusted Life Year (DALY) values calculated in a global WHO-led study (Havelaar et al. 2015; WHO 2015), with per capita income estimates for Indonesia used as a multiplier, reached broadly similar COI estimates (Table 2). Such estimations are generally in line in their magnitude with those from other countries (Table 4, overleaf).

The DALY-based estimate has a higher per capita value, since it accounts for longer-term sequelae, such as polyneuropathic disorders (eg. Guillain-Barré syndrome) or liver damage arising from FBI. It should be noted that the DALY metric was not originally designed as a measure to directly estimate costs of illness, but to quantify and standardise health impacts from diverse diseases "for use

in planning and evaluating the health sector" (Murray 1994). The use of the monetised DALY metric in the current study does not advocate for its use in this regard and was included only as a comparator to the Indonesian model to broadly test the validity of the latter, since it used a different

Table 4. Cost-of-FBI estimates and their sources.

Country	Source of estimate	Value
United States	Scharff, 2012	77.7 Billion USD
United Kingdom	UK FSA, 2011	1.5 B GBP
Sweden	Edenstein et al. 2016	1.0 B Euro
Australia	Kirk et al. 2008	1.14 B USD
New Zealand	Gadiel and Abelson 2010	162 M NZD
Indonesia	This report	5.4 – 17 B USD

methodology. That all of the estimates in this study are of the same level of magnitude suggests that diarrhoeal foodborne disease has major health and cost impacts to the people of Indonesia. Indeed, since the DALY metric largely accounts for indirect health costs, the actual cost impacts of illness are likely to be substantively higher.

4.2. Exclusions from cost-of-illness estimates.

The COI estimates do not include the cost of maintaining surveillance or regulatory networks to identify and contain FBI, product recalls or export losses. Such costs are not trivial and add to the overarching financial impact of FBI to Indonesia. Indeed, data from the Indonesian Statistics Agency (cited by the Global Business Guide Indonesia, at http://www.gbgindonesia.com/en/manufacturing/article/2014/thirst_quenching_Indonesia_s_food_andamp_beverage_industry.php) indicate an expanding market in exported foods from Indonesia valued at $4.83 billion USD. Market expansion could readily be curtailed by FBI agents present in foodstuffs that breach regulatory standards or damage trust.

4.3. Estimates for the burden of foodborne diarrhoeal illness in Indonesia.

Differences in the numbers of estimated FBI cases are evident among the models. The WHO FBI estimates for Indonesia were derived from regional, not country-specific data that were lacking. The Indonesian study of Agtini et al. (2005) examined for relatively few pathogens, hence WHO-derived evaluations of FBI pathogen prevalence were used in the current study to help attribute and

thus estimate, proportions of illness from food. A range of underreporting multipliers in the Agtini et al. (2005) data reworking (Tables 2 and 3) were selected to represent a spectrum of rates in a range reported in other studies (Table 1): given some of these reported values, higher multipliers would be justified. These factors account for the difference in FBI cases estimated from 10, 189,312 to 22,476,423 p.a. (Table 3). As expected (WHO 2008a), such estimates are greater than cases related to outbreaks, as used in the original Rahayu et al. (2016) modelling. Given the complexities of calculating the cost of foodborne illness, comparisons among different countries is equally challenging (McLinden et al. 2014), hence the WHO decision to base such comparisons on DALYs (Havelaar et al. 2015, WHO 2015). Nonetheless, a tabulation of recent COI estimates is enlightening, providing additional, independent evaluations of the cost impact of FBI (Table 4). However, more accurate estimates of impacts and attribution of FBI agents in Indonesia require further investigations of their prevalence and distribution in patients and foodstuffs.

5. Concluding remarks

The causes of FBI are myriad. The WHO (2008) listed over 100 different microbial, parasitic and chemical FBI causes, yet even this was not exhaustive. Microorganisms such as *Arcobacter butzleri, A. skirrowii, A. cryaerophilus, Cronobacter sakazakii, Helicobacter pullorum, Vibrio parahaemolyticus* and *V. vulnificus* are established or implicated foodborne pathogens, and once foodborne pathogenic species in the genera *Campylobacter, Cryptosporidum, Salmonella,* and *Yersinia* are individualised, and additional pathogenic types of *Escherichia coli* and Norovirus considered, the list of known individual foodborne hazards approaches 200. Additional, as-yet undetermined causes, cannot be ruled out. No single study is able to account for every known hazard and substantive proportions of diarrhoea go undiagnosed in every country, every year. It is a reasonable presumption that a percentage of these undiagnosed cases are due to FBI agents. Hence, any estimation of FBI and associated COI will most likely be an underestimation. Since the WHO estimate of global FBI due to 31 defined hazards was for 600 million cases per annum (Havelaar et al. 2015; WHO 2015), that is a sobering thought. The magnitude of these estimates warrant further consideration for action. Additional data on the prevalence of FBI agents in the Indonesian population and in their foodstuffs would be invaluable for more accurate information for action.

Acknowledgements

Stephen On thanks the Global Food Safety Partnership for funding this study. Professor Arie Havelaar (University of Florida, USA), Dr. Robin Lake (Institute of Environmental Science and Research, New Zealand), Dr. Eli Khanipour, Professor Steve Flint, Professor Hamish Gow and Graham Robinson (Massey University, New Zealand) are thanked for their input and advice on aspects of this paper.

References

Agtini, M.D., Soeharno, R., Lesmana, M., Punjabi, N.H., Simanjuntak, C., Wangsasaputra, F., Nurdin, D., Pulungsih, S.P., Rofiq, A., Santoso, H., Pujarwoto, H., Sjahrurachman, A., Sudarmono, P., von Seidlein, L., Deen, J.L., Ali, M., Lee, H., Kim, D.R., Han, O., Park, J.K., Suwandono, A., Ingerani, Oyofo, B.A., Campbell, J.R., Beecham, H.J., Corwin, A.L., and Clemens, J.D. (2005). The burden of diarrhoea, shigellosis, and cholera in North Jakarta, Indonesia: findings from 24 months surveillance. *BMC Infectious Diseases*, 5, 89. Erratum in: *BMC Infectious Diseases,* 7, 1.

Cressey, P., and Lake, R. (2008). Risk Ranking: Estimates of the cost of foodborne disease for New Zealand. *Report for the New Zealand Food Safety Authority*. Available online: http://www.foodsafety.govt.nz/elibrary/industry/risk-ranking-estimates-research-projects/FW07102_COI_estimates_final.pdf. (Accessed on 10 December 2016)

Devleesschauwer, B., Haagsma, J.A., Angulo, F.J., Bellinger, D.C., Cole, D., Döpfer, D., Fazil, A., Fèvre, E.M., Gibb, H.J., Hald, T., Kirk, M.D., Lake, R.J., Maertens de Noordhout, C., Mathers, C.D., McDonald, S.A., Pires, S.M., Speybroeck, N., Thomas, M.K., Torgerson, P.R., Wu, F., Havelaar, A.H., and Praet, N. (2015). Methodological framework for world health organization estimates of the global burden of foodborne disease. *PLoS One,* 10 (12), e0142498.

Edelstein, M., Merk, H., Deogan, C., Carnahan, A., and Wallensten, A. (2016). Quantifying the incidence and cost of acute gastrointestinal illness in Sweden, 2013-2014. *Epidemiology and Infection,* 144, 2831-2839.

FAO/WHO [Food and Agriculture Organisation/World Health Organisation]. (2011). Risk assessment series 16: *Vibrio parahaemolyticus* in seafood. ISSN 1726-5274.

Fletcher, S.M., Lewis-Fuller, E., Williams, H., Miller, Z., Scarlett, H.P., Cooper, C., Gordon-Johnson, K.A., Vickers, I., Shaw, K., Wellington, I., Thame, J., Pérez, E., and Indar, L. (2013). Magnitude, distribution, and estimated level of underreporting of acute gastroenteritis in Jamaica. *Journal of Health, Population and Nutrition,* 4, 69-80.

Gadiel, D., and Abelson, P. (2010). The Economic Cost of Foodborne Disease in New Zealand. *Report for the New Zealand Food Safety Authority.* Available online: http://www.foodsafety.govt.nz/elibrary/industry/economic-cost-foodborne-disease/foodborne-disease.pdf. (Accessed on 4 January 2017)

Glasgow, L.M., Forde, M.S., Antoine, S.C., Pérez, E., and Indar, L. (2013). Estimating the burden of acute gastrointestinal illness in Grenada. *Journal of Health, Population and Nutrition*, 4, 17-29.

Hald, T., Aspinall, W., Devleesschauwer, B., Cooke, R., Corrigan, T., Havelaar, A.H., Gibb, H.J., Torgerson, P.R., Kirk, M.D., Angulo, F.J., Lake, R.J., Speybroeck, N., and Hoffmann, S. (2016). World Health Organization estimates of the relative contributions of food to the burden of disease due to selected foodborne hazards: a structured expert elicitation. *PLoS One,* 11 (1), e0145839.

Havelaar, A.H., Kirk, M.D., Torgerson, P.R., Gibb, H.J., Hald, T., Lake, R.J., Praet, N., Bellinger, D.C., de Silva, N.R., Gargouri, N., Speybroeck, N., Cawthorne, A., Mathers, C., Stein, C., Angulo, F.J., and Devleesschauwer, B. (2015). World Health Organization foodborne disease burden epidemiology reference group. World Health Organization Global Estimates and Regional Comparisons of the Burden of Foodborne Disease in 2010. *PLoS Medicine* 12 (12), e1001923.

Kirk, M.D., McKay, I., Hall, G.V., Dalton, C.B., Stafford, R., Unicomb, L., and Gregory, J. (2008). Food safety: foodborne disease in Australia: the OzFoodNet experience. *Clinical Infectious Diseases*, 47, 392-400.

Kirk, M.D., Pires, S.M., Black, R.E., Caipo, M., Crump, J.A., Devleesschauwer, B., Döpfer, D., Fazil, A., Fischer-Walker, C.L., Hald, T., Hall, A.J., Keddy, K.H., Lake, R.J., Lanata, C.F., Torgerson, P.R., Havelaar, A.H., and Angulo, F.J.. (2015). World Health Organization estimates of the global and regional disease burden of 22 foodborne bacterial, protozoal, and viral diseases, 2010: a data synthesis. *PLoS Medicine* 12 (12), e1001921.

Lake, R., Adlam, B., and Perera, S. (2009). Acute Gastrointestinal Illness (AGI) Study: Final study report. *Report for the New Zealand Food Safety Authority.* Available online: http://www.foodsafety.govt.nz/elibrary/industry/acute-illness-study-gastrointestinal-report/Final_Report.pdf. (Accessed on 4 January 2017)

MacDougall, L., Majowicz, S., Doré, K., Flint, J., Thomas, K., Kovacs, S., and Sockett, P. (2008). Under-reporting of infectious gastrointestinal illness in British Columbia, Canada: who is counted in provincial communicable disease statistics. *Epidemiology and Infection,* 136, 248-256.

Majowicz, S.E., Edge, V.L., Fazil, A., McNab, W.B., Doré, K.A., Sockett, P.N., Flint, J.A., Middleton, D., McEwen, S.A., and Wilson JB. (2005). Estimating the under-reporting rate for infectious gastrointestinal illness in Ontario. *Canadian Journal of Public Health*, 96, 178-181.

Murray, C.J.L. (1994). Quantifying the burden of disease: the technical basis for disability-adjusted life years. *Bulletin of the World Health Organization,* 72, 429-445.

McLinden, T., Sargeant, J.M., Thomas, M.K., Papadopoulos, A., and Fazil, A. (2014). Component costs of foodborne illness: a scoping review. *BMC Public Health*, 14, 509.

Persuad, S., Mohamed-Rambaran, P., Wilson, A., James, C., and Indar L. (2013). Determining the community prevalence of acute gastrointestinal illness and gaps in surveillance of acute gastroenteritis and foodborne diseases in Guyana. *Journal of Health, Population and Nutrition,* 4, 57-68.

Rahayu, W.P., Fardiaz, D., Kartika, G.D., Nababan, H., Fanaike, R., and Puspitasari, R. (2016). Estimation of economic losses of food poisoning outbreaks. *Food Science and Biotechnology,* 25, 157-161.

Scharff, R.L. (2012). Economic burden from health losses due to foodborne illness in the United States. *Journal of Food Protection,* 75, 123-31.

Tam, C.C., Rodrigues, L.C., Viviani, L., Dodds, J.P., Evans, M.R., Hunter, P.R., Gray, J.J., Letley, L.H., Rait, G., Tompkins, D.S., O'Brien, S.J, and the IID2 Study Executive Committee. (2012). Longitudinal study of infectious intestinal disease in the UK (IID2 study): incidence in the community and presenting to general practice. *Gut,* 61, 69-77.

UKFSA [UK Food Standards Agency]. (2011). Foodborne disease strategy 2010-2015. Available online: http://www.food.gov.uk/sites/default/files/multimedia/pdfs/fds2015.pdf (Accessed on 4 January 2017)

Wheeler, J.G., Sethi, D., Cowden, J.M., Wall, P.G., Rodrigues, L.C., Tompkins, D.S., Hudson, M.J., and Roderick, P.J. (1999). Study of infectious intestinal disease in England: rates in the community, presenting to general practice, and reported to national surveillance. The Infectious Intestinal Disease Study Executive. *British Medical Journal,* 318, 1046-1050.

WHO [World Health Organisation]. (2008a). First formal meeting of the Foodborne Disease Burden Epidemiology Reference Group (FERG): implementing strategy, setting priorities and assigning the tasks. World Health Organisation (Publishers), ISBN 978 92 4 159676 3.

WHO [World Health Organisation]. (2008b). Foodborne disease outbreaks: guidelines for investigation and control. World Health Organisation (Publishers), ISBN 978 92 4 154722 2.

World WHO [World Health Organisation]. (2015). WHO estimates of the global burden of foodborne diseases. Full report. World Health Organisation (Publishers), ISBN 978 92 4 156516 5.
