Ministry for Primary Industries
Manatū Ahu Matua

Expert elicitation-derived estimates of foodborne proportions of enteric illnesses

MPI Technical Report – Paper No: 2016/38

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ISBN No: 978-1-77665-317-1 (online)
ISSN No: 2253-3923 (online)

June 2013

New Zealand Government

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Scientific Interpretive Summary

This SIS is prepared by MPI risk assessors to provide context to the following report for MPI risk managers and external readers

Expert elicitation-derived estimates of foodborne proportions of enteric illnesses
FW13032

Enteric infectious diseases are common in New Zealand, cause considerable illness and suffering, are economically costly and reflect on New Zealand's primary industries. Working out the best strategies to control enteric diseases is difficult because these illnesses can be caused by many different things. For instance some enteric diseases can be caused through consumption of contaminated food, through contact with infected animals or people, or through exposure to contaminated environments. To help prioritise strategies, it is important to understand the proportions of enteric illnesses that are likely to be due to transmission through the food supply, i.e., the foodborne proportions.

Determining the foodborne proportions of enteric diseases is problematic. Routine interviews and investigations of individual cases are of limited value because transmission of infection can occur at least several days prior to onset of illness, and multiple possible causes of illness may have occurred in this time. Information from disease outbreaks can be useful, but these account for a small minority of overall cases. More exacting studies using microbiological or epidemiological techniques provide valuable data, but tend to focus on specific illnesses and do not cover the entire breadth of enteric diseases.

Expert elicitation is a systematic approach to obtaining subjective views from experts on a subject where there is uncertainty due to insufficient data or when such data are unattainable. This technique draws on the unpublished knowledge and wisdom held by experts, based on their accumulated experience and expertise. Estimating the foodborne proportions of enteric diseases is an appropriate application of expert elicitation techniques. The MPI commissioned a project in 2013 to use expert elicitation to estimate the foodborne proportions of enteric infections with nine different pathogens: *Campylobacter*, L*isteria monocytogenes*, *Norovirus*, *Salmonella*, STEC O157, non-O157 STEC, *Toxoplasma gondii*, *Vibrio parahaemolyticus* and *Yersinia enterocolitica*. For some pathogens, the contribution of specific foods was considered; these included poultry, red meat, ready-to-eat meat, seafood and pork. The methods and scope of this project were very similar to those employed in a 2005 expert elicitation project.

A panel of New Zealand-based experts was gathered, covering disciplines such as food microbiology, veterinary medicine, health protection, surveillance and epidemiology, from a range of work sectors and institutions. Experts were asked to separately make their foodborne proportion estimates; the spread of estimates were discussed collectively, and the experts then provided a second round of estimates. No attempt was made to develop a consensus estimate for the panel as a whole. Instead, the individual estimates were aggregated. In one aggregation, estimates were weighted according to the self-estimate of expertise by the experts.

According to the expert elicitation findings, pathogens in New Zealand with the highest proportions of illness due to foodborne transmission were as follows (in decreasing order): *Vibrio parahaemolyticus* (90.6%), *Listeria monocytogenes* (87.8%), *Campylobacter* (63.8%), *Yersinia enterocolitica* (63.2%), *Salmonella* (62.1%), non-O157 STEC (34.0%), *Norovirus* (32.7%), STEC O157 (29.9%) and *Toxoplasma gondii* (27.6%). Estimates provided here are those aggregated following weighting by the experts' assessments of their expertise with each pathogen.

Comparisons between the findings of the 2013 and the 2005 respective expert elicitation projects need to be considered in the context of developments in research in intervening years. This is particularly apparent for campylobacteriosis. In the years immediately after the 2005 expert elicitation project was completed, substantial advances in research methodologies occurred that enabled more detailed estimates of the contribution of different animal reservoirs to *Campylobacter* infection rates. This work indicated that the contribution from poultry before 2007 was likely to have been much higher than previously considered. Between 2006 and 2008, substantial reductions occurred in both the overall campylobacteriosis rate and the proportion attributable to poultry, largely considered due to implementation of interventions to reduce *Campylobacter* contamination on poultry meat: analysis of campylobacteriosis rates in combination with source attribution data has suggested that, in 2008, approximately 9000 fewer people were notified with campylobacteriosis due to contaminated poultry than had occurred in 2006.

The 2013 expert elicitation findings have taken this into account, and provide an estimate of the foodborne proportion of campylobacteriosis that is consistent with current findings from source attribution research: notably, there was more convergence around the individual experts' estimates of the foodborne proportion of campylobacteriosis than for other pathogens.

This example illustrates that expert elicitation estimates reflect knowledge at a point in time, and must be interpreted as such.

EXPERT ELICITATION: FOODBORNE TRANSMISSION OF ENTERIC PATHOGENS IN NEW ZEALAND

Client report FW13032

by

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EXPERT ELICITATION: FOODBORNE TRANSMISSION OF ENTERIC PATHOGENS IN NEW ZEALAND

Prepared for the Ministry for Primary Industries
under project MRP/12/04 - Expert Elicitation: Foodborne transmission of enteric pathogens, as part of an overall contract for scientific services

Client report no. FW13032

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June 2013

ACKNOWLEDGEMENTS

The authors would like to thank the participants in the MPI Expert Elicitation for the time, effort and expertise that they contributed to the completion of elicitation questionnaire and their participation in the workshop on the attribution of gastro-intestinal disease to food/hazard combinations, held at ESR Kenepuru Science Centre on 5 June 2013. Participants were Greg Simmons (Taranaki DHB), Tui Shadbolt (MidCentral DHB), Nigel French (Massey University), Maurice Wilson, Ruth Pirie, Brent Gilpin, Andrew Hudson (all ESR), Roger Cook (MPI), Donald Campbell and Petra Muellner (Independent Consultants).

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SUMMARY

Expert elicitation refers to a systematic approach to obtaining and synthesising subjective judgments from experts on a subject where there is uncertainty due to insufficient data or when such data are unattainable because of physical constraints or lack of resources. It seeks to make explicit and usable the unpublished knowledge and wisdom held by the experts, based on their accumulated experience and expertise. This may include insights into the limitations, strengths and weaknesses of the published knowledge and available data. Usually the subjective judgment is represented as a subjective probability density function (SPD), reflecting the expert's belief regarding the quantity at hand and their level of confidence in that belief. An expert elicitation procedure should be developed in such a way that minimises inherent biases in subjective judgment and errors related to that in the elicited outcomes.

The current study aimed to utilise a scientifically justified methodology for an expert elicitation process to provide updated source attribution for foodborne hazards in New Zealand. The methodology developed was informed by a preceding review of international best practice. The scope of the elicitation, in terms of the pathogens and foods for which estimates were required, was agreed with the Ministry for Primary Industries (MPI) at the start of the process. Pathogens included were *Campylobacter*, *Listeria monocytogenes*, norovirus, *Salmonella* (non-typoidal), STEC O157, non-O157 STEC, *Toxoplasma gondii*, *Vibrio parahaemolyticus* and *Yersinia enterocolitica.* Specific foods considered include poultry, red meat, ready-to-eat meat, seafood and pork.

The elicitation was conducted as a two-round Delphi with a panel of 10 experts, allowing feedback of first round aggregated results and revision of estimates, but with no attempt made to generate a consensus value for estimates. Each round consisted of completion of a questionnaire.

The first round was conducted by e-mail in late May 2013, with the second round conducted as a facilitated face-to-face meeting on 5 June 2013. During the e-mail phase, participants were able to direct questions concerning the completion of the questionnaire to the study co-ordinators. The questions and associated answers were distributed to all participants.

During the face-to-face meeting, participants were given the opportunity to discuss the outputs from the first round. Participants were particularly encouraged to discuss any extreme results from the first round. In this context, 'extreme' refers to results that differ markedly from the other panel results for a particular question. Followed facilitated discussions, participants were given an opportunity to update their opinions by repeating the elicitation questionnaire.

Estimates were aggregated in three ways: equal weighting, weighting according to self-assessment of expertise by the experts, and performance based weighting based on estimates for a set of calibration questions presented at the start of the face to face meeting. The last aggregation approach resulted in the opinions of only three experts being used.

Overall results are given below, along with estimates from a previous elicitation conducted in 2005.

Pathogen	Quantity estimated	Mean aggregate estimate (%), based on weighting scheme (95th percentile credible interval)			Mean aggregate estimate from 2005 study (95th percentile credible interval)
		Uniform	Self-assessed	Performance-based	
Campylobacter	% Foodborne	62.6 (43.4-82.5)	63.8 (44.1-83.2)	61.0 (49.3-68.8)	56.2 (26-82)
Campylobacter	% Poultry	74.1 (49.0-91.2)	75.4 (51.6-91.2)	62.9 (45.8-84.7)	52.9 (14-75)
Listeria monocytogenes	% Foodborne	86.3 (52.8-98.5)	87.8 (57.9-98.5)	92.5 (83.2-98.9)	85.0 (48-100)
Listeria monocytogenes	% RTE Meat	54.1 (27.7-86.2)	55.2 (29.9-87.7)	49.6 (32.2-70.7)	53.9 (16-80)
Norovirus	% Foodborne	33.8 (9.1-65.7)	32.7 (10.0-66.4)	20.9 (8.4-32.0)	39.2 (8-64)
Norovirus	% Seafood	24.6 (3.7-54.8)	24.4 (3.9-54.7)	17.1 (3.6-26.5)	40.0[1] (11-78)
Salmonella	% Foodborne	61.2 (34.2-86.0)	62.1 (35.2-86.4)	69.2 (36.5-83.9)	59.6 (18-83)
Salmonella	% Poultry	18.7 (3.1-55.8)	19.2 (3.0-56.5)	19.4 (6.4-34.6)	35.7 (16-73)
STEC O157	% Foodborne	31.0 (3.8-60.1)	29.9 (3.5-60.7)	40.1 (12.7-57.8)	39.5[2] (6-95)
STEC O157	% Red meat	33.2 (5.6-63.9)	33.5 (4.4-64.6)	33.3 (14.8-46.9)	30.6[2] (3-60)
Non-O157 STEC	% Foodborne	36.4 (3.8-64.0)	34.0 (3.5-63.5)	41.4 (13.1-63.8)	39.5[2] (6-95)
Non-O157 STEC	% Red meat	27.9 (1.4-64.5)	27.1 (1.2-65.9)	25.5 (11.9-48.6)	30.6[2] (3-60)
Toxoplasma gondii	% Foodborne	25.3 (3.6-55.6)	27.6 (3.8-57.1)	41.7 (25.2-60.2)	31.5 (3-82)
Vibrio parahaemolyticus	% Foodborne	89.0 (55.7-99.8)	90.6 (56.9-99.9)	97.3 (84.2-100)	89.2 (64-100)
Vibrio parahaemolyticus	% Seafood	92.9 (68.3-100)	93.8 (70.3-100)	98.4 (88.3-100)	89.2 (57-100)
Yersinia enterocolitica	% Foodborne	62.1 (27.2-91.4)	63.2 (29.0-91.5)	75.8 (58.1-93.2)	56.2 (32-92)
Yersinia enterocolitica	% Pork	71.7 (36.6-93.2)	71.1 (36.8-93.1)	56.7 (34.0-75.2)	52.9 (30-74)

Note that the percentage of transmission attributed to specific foods, is a proportion of the foodborne attribution
[1] Estimate relates to shellfish only
[2] For all STEC genotypes

1 INTRODUCTION

Expert elicitation refers to a systematic approach to obtaining and synthesising subjective judgments from experts on a subject where there is uncertainty due to insufficient data or when such data are unattainable because of physical constraints or lack of resources. It seeks to make explicit and usable the unpublished knowledge and wisdom held by the experts, based on their accumulated experience and expertise. This may include insights into the limitations, strengths and weaknesses of the published knowledge and available data. Usually the subjective judgment is represented as a subjective probability density function (SPD), reflecting the expert's belief regarding the quantity at hand and their level of confidence in that belief. An expert elicitation procedure should be developed in such a way that minimises inherent biases in subjective judgment and errors related to that in the elicited outcomes.

In risk analysis, use of expert opinion is often inevitable, due to the lack of information on variables of interest (Ouchi, 2004).

Expert opinions can be used for two broad purposes (Slottje *et al.*, 2008):

- To structure a problem. Experts determine which data and variables are relevant for analysis, which analytical methods are appropriate and which assumptions are valid.
- To provide estimates. For example, experts may estimate failure or incidence rates, determine weighting for combining data sources, or characterise uncertainty.

Most expert elicitations fulfil the latter purpose – eliciting an estimate of some variable quantity in some particular context. The investigator is usually interested in the expert's estimate of some quantity and their associated confidence in their opinion.

Expert elicitation has previously been used in New Zealand (Cressey and Lake, 2005) and internationally (Davidson *et al.*, 2011; Havelaar *et al.*, 2008; Hoffmann *et al.*, 2007; 2008; Ravel *et al.*, 2010) in the food safety domain to elicit opinions on the proportion of disease due to various microbial pathogens that is due to transmission by food.

Source attribution estimates are important for risk ranking and policy development by MPI. In 2005 an expert elicitation was carried out to derived estimates for foodborne attribution for a range of pathogens. The previous set of estimates have contributed for the last five years to MPI's monitoring of progress against their performance targets to campylobacteriosis, salmonellosis and listeriosis (Lim *et al.*, 2010; Lim *et al.*, 2011; Lim *et al.*, 2012; Williman *et al.*, 2008; Williman *et al.*, 2009). Previous estimates have also been used in estimates of the burden of foodborne disease for New Zealand (Cressey and Lake, 2011; Lake *et al.*, 2010).

1.1 Current Study

The current study aimed to utilise a scientifically justified methodology for an expert elicitation process to provide updated source attribution for foodborne hazards in New Zealand. The methodology developed was informed by a preceding review of international best practice (Cressey and Lake, 2012). The scope of the elicitation, in terms of the pathogens and foods for which estimates were required, was agreed with the Ministry for Primary Industries (MPI) at the start of the process. Pathogens included were *Campylobacter*, *Listeria monocytogenes*, norovirus, *Salmonella* (non-typoidal), STEC O157, non-O157

STEC, *Toxoplasma gondii*, *Vibrio parahaemolyticus* and *Yersinia enterocolitica*. Specific foods considered include poultry, red meat, ready-to-eat meat, seafood and pork.

The elicitation was designed to provide estimates for the proportions of the incidence of specific enteric diseases in New Zealand that were due to transmission by food. In addition estimates were sought for the proportion of the foodborne burden that was due to transmission by specific foods.

2 EXPERT ELICITATION METHODS

While the study is concerned with disease, in this report reference will usually be made to the organism causing the disease. For example, for the disease campylobacteriosis, reference will generally be made to the organism *Campylobacter*.

2.1 Organisms Included in the Study

Bacteria: *Campylobacter*, *Escherichia coli* O157, *Listeria monocytogenes*, non-Typhi *Salmonella*, non-O157 STEC serotypes, *Vibrio parahaemolyticus*, *Yersinia enterocolitica*

Parasites: *Toxoplasma gondii*

Viruses: Norovirus

Note: The sources of *Campylobacter* have been explored extensively in recent years using genetic typing. However, transmission pathways have been only partially addressed. Addressing *Campylobacter* as part of the expert elicitation supplements existing transmission route estimates.

2.2 Transmission Routes Considered

While the study is primarily concerned with foodborne transmission, participants were also asked to either:

- Assign the total incidence of disease across five potential transmission routes, or
- Indicate the relative order of contribution of five potential transmission routes.

This exercise was included in the elicitation to support estimation of the foodborne proportion, by stimulating certain cognitive processes. It is an adaptation of a process used in a Dutch expert elicitation (Havelaar *et al.*, 2008). By explicitly considering several transmission routes, it was hoped to avoid overestimation or underestimation for the foodborne route, and to prevent confusion about the definition of waterborne transmission. It was believed that this would assist in generating internal consistency in attribution estimates, as experts would need to consider questions such as "If not food, what is the transmission route?" and "If a proportion of the transmission is due to other routes, how much is reasonably due to food?".

The transmission routes considered and their definitions are included in Table 1.

Table 1: Definition of transmission routes included in 2013 expert elicitation

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, livestock processing plants, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). **This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.**
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Definitions were adapted from the Dutch study of Havelaar *et al.* (2008). For the New Zealand study, 'water' was defined as a separate transmission route, rather than including it as a component of environmental transmission. The definition for 'animal contact' was further elaborated to specify the inclusion of transmission by 'working at livestock processing plants'. The Dutch study included 'travel-associated' as a transmission route, while the current study specifically focussed on attributing domestically-acquired disease.

The definitions included in Table 1 were carefully worded to avoid any ambiguities. Drafting of the definitions drew on the earlier New Zealand expert elicitation (Cressey and Lake, 2005), definitions used in similar international studies (Davidson *et al.*, 2011; Havelaar *et al.*, 2008; Hoffmann *et al.*, 2006) and feedback from pilot testing of the survey questionnaire. For example, based on discussions at the 2005 expert elicitation, bottled water was defined as a food to avoid participant uncertainty as to whether it should be included under 'food' or 'water'.

2.3 Specific Hazard-Food Combinations Considered

In addition to estimating the overall proportion of disease due to foodborne transmission of the selected enteric pathogens, MPI wished to examine the proportion of disease attributable to commonly cited food vehicles. Pathogen/food vehicle combinations included were:

- *Campylobacter*: poultry, red meat
- *Listeria monocytogenes*: ready-to-eat meats
- Norovirus: seafood
- Non-Typhi *Salmonella*: poultry, red meat
- STEC O157: red meat
- STEC non-O157: red meat

- *Vibrio parahaemolyticus*: seafood
- *Yersinia enterocolitica*: pork

Definitions of these foods were included in the Elicitation Introduction and Elicitation Questionnaire provided to participants (see Appendix 1).

2.4 Selection of Expert Panel

Research has shown little or no improvement in the aggregate opinions of panels with more than ten experts (Knol *et al.*, 2010; Shirazi, 2009; United States Environmental Protection Agency, 2011). Given the modest size of the New Zealand scientific community related to foodborne disease, an expert panel of this size was considered appropriate.

A list of experts was assembled, in consultation with MPI, based on the following criteria:

- New Zealand-based
- Evidence of expertise (e.g. publications, field of employment)
- Reputation in the required area of expertise
- Impartiality (no conflict of interest)

Each expert on this list was asked to suggest three other experts who they believed met the selection criteria (a 'snowball' technique). This process quickly achieved an internally consistent set of potential participants. The final panel was selected on the basis of availability and providing a range of organisational affiliations.

The final panel included 10 individuals. The 10 participants were from the following types of organisations:

- University 1
- Regulatory agency 1
- Crown Research Institute 4
- Public Health Unit 2
- Private consultancy 2

Of the 10 participants, 4 had participated in the earlier New Zealand expert elicitation in 2005 (Cressey and Lake, 2005).

2.5 Elicitation Method and Participant Interaction

The elicitation was conducted as a two-round Delphi (Gallagher *et al.*, 2002; Helmer, 1967), allowing feedback of first round aggregated results and revision of estimates, but with no attempt made to generate a consensus value for estimates. Each round consisted of completion of the questionnaire (see Appendix 1).

The first round was conducted by e-mail in late May 2013, with the second round conducted as a facilitated face-to-face meeting on 5 June 2013. During the e-mail phase, participants were able to direct questions concerning the completion of the questionnaire to the study co-ordinators. The questions and associated answers were distributed to all participants.

During the face-to-face meeting, participants were given the opportunity to discuss the outputs from the first round. Participants were particularly encouraged to discuss any extreme results from the first round. In this context, ‘extreme’ refers to results that differ markedly from the other panel results for a particular question. Following facilitated discussions, participants were given an opportunity to update their opinions by repeating the elicitation questionnaire.

2.6 Assessment of Participant Expertise

Two techniques were used to measure individual’s expertise.

2.6.1 Participant self-assessment

Participants were asked to assess their own level of expertise with respect to each of the nine organisms included in the elicitation. Assessment was reported on a five-point Likert scale as usually in a US attribution expert elicitation (Hoffmann *et al.*, 2006), with three defined scale points:

1 = low expertise – no direct experience, anecdotal knowledge only
3 = medium expertise – some direct experience, wide reading
5 = high expertise – primary focus of professional work

Participants were also given the opportunity to refrain from answering questions on specific organisms, if they felt that their level of expertise was negligible.

2.6.2 Calibration

A series of seven questions were prepared relating to foodborne disease risk or prevalence of foodborne hazards in Australia and New Zealand. The parameters were chosen on the basis that, although their value was known, and the parameter was relevant to the field of foodborne disease, the experts chosen would be unlikely to know the exact value at the time of the elicitation. The calibration questionnaire has been included in Appendix 2. The quantities for which estimates were elicited are generally referred to as seed variables.

Performance in estimating the known values of seed variables under uncertainty was used to derive two quantitative measures of performance, calibration and information (Cooke and Goossens, 2000; Cooke and Goossens, 2008).

Calibration is a measure of the statistical likelihood that a set of experimental results correspond with a particular expert’s opinion. It can be viewed as a measure of how accurate or ‘well calibrated’ the expert’s opinions are. It is defined as the p-value of a standard chi-squared goodness of fit test.

Information is a measure of how concentrated the expert’s distribution is relative to some user-selected background measure (e.g. a uniform distribution). It can be viewed as a measure of the precision of the expert’s opinions.

2.7 Elicitation

Three categories of opinion were elicited for each pathogen of interest (see questionnaire in Appendix 1):

- The proportion of cases of disease due to the pathogen that are due to foodborne transmission;
- The proportion of cases of disease due to the pathogen that are due to each of five transmission routes (see section 2.2) OR the ranking of the transmission routes with respect to their contribution to the total number of disease cases; and
- The proportion of foodborne cases that are due to specific, defined foods.

It should be noted that for *Toxoplasma gondii* no specific foods were addressed.

Estimates for part 1 and part 3 above were elicited using a four-point method (Speirs-Bridge *et al.*, 2010) that asked participants for a minimum, maximum and most likely estimate, in that order. They are then asked to express their confidence in the defined interval (minimum-maximum) in terms of the percentage of occasions they felt the true value would fall within their defined interval. It should be noted that participants estimates were not required to be of the form minimum < most likely < maximum. In some cases, participants most likely estimates were coincident with either their minimum or maximum estimates.

The reference year for the estimates was 2012.

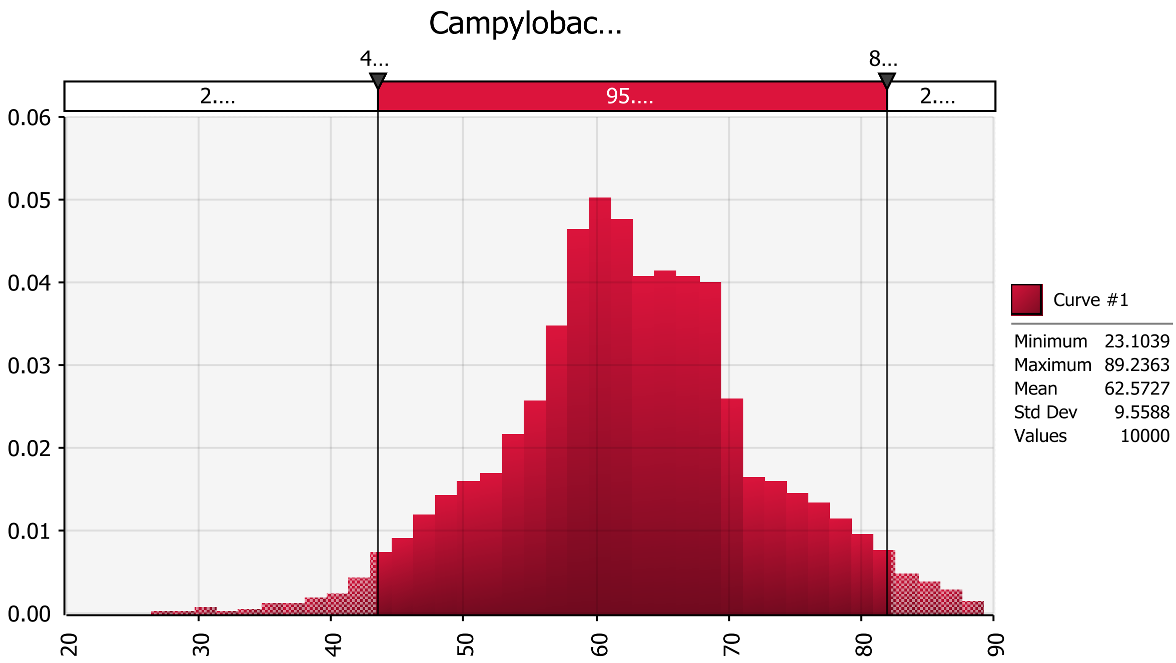
2.8 Post Elicitation Analysis

2.8.1 Aggregation of opinions

The final output was a mathematical combination of estimates from experts who consider themselves well enough informed, with respect to the particular pathogen/disease. Opinions of individual experts were encoded as a pert distribution, with parameters minimum, most likely and maximum. Individual opinion distributions were combined by Monte Carlo simulation modelling using the Excel add-in @Risk (Palisades Corporation).

Figure 1 shows an example output of the simulation for aggregation of individual opinions.

Figure 1: **Aggregation of individual expert opinions of the proportion of *Campylobacter* infection cases that are foodborne, using uniform weighting (*n* = 10,000 iterations)**



2.8.1.1 Weighting of opinions

Simulations were carried out using a range of weighting schemes including equal weighting, self-assessed expertise weighting, and weighting using results from a set of calibration questions (second round only).

Participants' self-assessed expertise rating (1-5) was used directly as a weighting factor. In other words, the simulation selects from the subjective probability distribution of a participant self-assessed as a rating of 5 five-times as frequently as from the subjective probability distribution of a participant self-assessed as a rating of 1.

The performance-based calibration weights derived from analysis of performance in estimating seed variables are proportional to the product of calibration and information. For a set of experts, these performance based weights can be optimised. This involves definition of a 'cut-off' weight. If an individual expert's performance on the seed variables results in a weighting below the cut-off weight, then that individual's opinion is not included in the final aggregation. The weights of the remaining experts are normalised to sum to one. The cut-off is varied iteratively until a composition and weighting of experts is achieved that maximises the score function on the seed variables. In other words, a combination of experts and weights is arrived at whose opinions when combined and weighted give the best overall agreement with the known values of the seed variables. This approach means that the final aggregated opinion of a panel of, for example, ten members may be based only on the opinions of two or three of those members.

Seed variables (n = 7) were derived from enteric disease studies in New Zealand and Australia. Performance-based weights were derived using the software package Excalibur V1.0.[1]

2.9 Comparisons to the 2005 New Zealand Expert Elicitation

The earlier (2005) New Zealand expert elicitation is used as a reference point for results from the current study (Cressey and Lake, 2005). The 2005 study was a two-round Delphi, with both rounds completed on a single day, at a face-to-face meeting. A discussion of the first round results was facilitated between the two rounds of questionnaire administration. No mechanism was included to the measure the level of expertise of participants. Opinions were elicited as three-point estimates (minimum, most likely, maximum). Participants were not given the option to 'opt out' of pathogen areas were they felt they didn't have sufficient expertise.

Individual opinions were represented by pert distributions and combined by simulation, using equal weighting.

The 2005 study did not include questions on transmission routes other than food.

[1] http://risk2.ewi.tudelft.nl/oursoftware/6-excalibur Accessed 7 June 2013

3 RESULTS AND DISCUSSION

3.1 Issues Identified

Despite the best efforts of the organisers, expert elicitation exercises often involve some unforeseen issues and misunderstandings. In our opinion, a face to face meeting is an essential element of an elicitation process, providing an opportunity to identify and resolve such issues. For the benefit of future expert elicitation exercises, the issues identified in this process, and their resolution, are documented here.

3.1.1 Food definitions

3.1.1.1 Offals

A participant asked whether offals were included or specifically excluded from the specific foods 'red meat' and 'poultry'. Reference to international elicitation exercises on foodborne attribution found that none of the studies specifically addressed this issue (Davidson *et al.*, 2011; Havelaar *et al.*, 2008; Hoffmann *et al.*, 2007). The Australia New Zealand Food Standards Code separately defines 'meat flesh' and 'offal', but both come under the broader definition of meat.[2] It was concluded that:

> For risk management purposes muscle meat and offal are likely to be subject to the same control measures within the same farming/processing industry sector. For the current expert elicitation, 'red meat' includes edible offals from cattle, small game animals (including rabbits), horse, deer and elk (wapiti), sheep and lamb, goat and pig. 'Poultry' includes edible offals from chickens (*Gallus gallus*), turkeys and ducks, but excludes offals from other types of poultry such as goose, pigeon and ostrich.

3.1.1.2 Poultry

Discussion occurred on whether 'poultry' includes contamination on the exterior of shell eggs, which may contaminate other foods when the egg is broken. It was concluded that:

> 'Poultry' would be taken to mean poultry meat, including offals, and other foods contaminated by poultry meat during food preparation.

3.1.2 Transmission route definitions

3.1.2.1 Animal slaughter and processing

Pilot testing of the questions raised a question as to whether disease acquired during animal slaughter should be considered to be 'animal contact' or 'food contact', as the situation is not dissimilar to that of a food handler. Transmission route definitions were amended to make it clear that transmission of this sort should be considered under 'animal contact'.

[2] http://www.comlaw.gov.au/Details/F2012C00286 Accessed 28 May 2013

3.1.2.2 Placental transmission

Discussion took place as to whether foetal cases of infection resulting from placental transmission of the organism in a mother infected through consumption of contaminated food should be considered as being due to the 'food' or 'human-to-human' transmission route. This question arose particularly with reference to invasive listeriosis. For the purpose of the current exercises such transmission was deemed to be foodborne. This decision was made, in part, due to the fact that the New Zealand notifiable disease system records foetal listeriosis cases in terms of the mother.

3.1.3 Confidence estimates for elicited intervals

The 2013 expert elicitation used a four-point procedure, in which participants were asked to define an interval (minimum-maximum), a most likely estimate from within the interval and an expression of confidence that their defined interval would contain the true value. Some participant responses indicated that the estimate of confidence was being viewed as how confident the participant was of their expertise in the subject area. In other words, confidence was being used as a second self-assessment of expertise.

The following explanatory note was forwarded to all participants:

> The question structure for the MPI expert elicitation asked the participant to define an interval (minimum – maximum) within which they believe the true value to lie. They are then further asked for a 'most likely' point estimate of the value of interest. Finally they are asked for an expression of their confidence that the interval they have defined contains the true value.
>
> In general it is likely that there will be some correlation between the width of the defined interval and the value for confidence in that interval. In completing the expert elicitation questionnaire, participants should consider the relative values of the interval defined and the level of confidence specified. For example, an interval of 20-70 cases out of 100 covers 50% of the available range. If the participant expresses 50% confidence in this estimate (i.e. the true value will lie in this range 50% of the time) then the participant is neutral about their estimate being correct. If the confidence estimate was less than 50% then the participant believes that the true value is more likely to fall outside their defined interval than inside it.
>
> As a guideline, the magnitude of the confidence expressed should be greater than the width of the interval defined (maximum – minimum) or no expertise is being expressed. For an expert elicitation such as the current one, the level of confidence should probably always be greater than 70%. If participants do not feel that confident that the defined interval will contain the true value, then they should consider defining a wider interval or consider declining to offer an opinion.

3.2 Measurement of Expertise

3.2.1 Self-assessed expertise

All participants were asked to provide an estimate of their expertise with respect to each pathogen of interest. Expertise was expressed on a five-point (Likert) scale. Participants' self-assessed expertise levels are summarised in Table 2.

Table 2: Participant self-assessed expertise

Pathogen	Number of experts in expertise category						Mean expertise score[2]
	NR[1]	1	2	3	4	5	
Campylobacter	0	0	1	2	4	3	3.9
Listeria monocytogenes	0	0	3	3	3	1	3.2
Norovirus	0	1	3	4	1	1	2.8
Salmonella	0	0	3	1	5	1	3.4
STEC O157	0	0	2	4	1	3	3.5
Non-O157 STEC	1	1	3	2	2	1	2.6
Toxoplasma gondii	4	0	5	0	1	0	1.4
Vibrio parahaemolyticus	3	0	4	2	1	0	1.8
Yersinia enterocolitica	1	0	3	4	2	0	2.6

[1] NR = No response. The participant felt they did not have sufficient expertise to provide opinions on questions related to this pathogen
[2] For the purpose of calculating a mean expertise score, 'NR' responses were assigned a value of zero

It is probably not surprising that the panel had their maximum strength, as measured by mean expertise score, relating to pathogens that are of immediate or recent interest in New Zealand (*Campylobacter*, STEC O157, *Salmonella* and *Listeria monocytogenes*).

An US study used the same five-point approach for participant self-assessment of expertise (Hoffmann *et al.*, 2006). The highest mean expertise scores were obtained for STEC O157 (3.89), *Salmonella* (3.73) and *Listeria monocytogenes* (3.65), while the lowest mean expertise score was for *Toxoplasma gondii* (1.98).

The Dutch study of Havelaar *et al.* (2008) employed a simpler system, in which participants could choose which pathogen they would provide opinions for. The pathogens with the highest number of responding participants were *Salmonella*, *Campylobacter*, *Listeria monocytogenes* and STEC O157.

3.2.2 Performance-based weights

Global performance-based weights were derived based on performance in estimating a series of seven seed variables. The optimised weighting scheme resulted in three participants being calibrated, with normalised weights of 0.65, 0.21 and 0.14. All aggregated estimates in the following section that use performance-based weights represent the weighted aggregation of the estimates from these three participants.

3.3 Opinions Related to Specific Pathogens

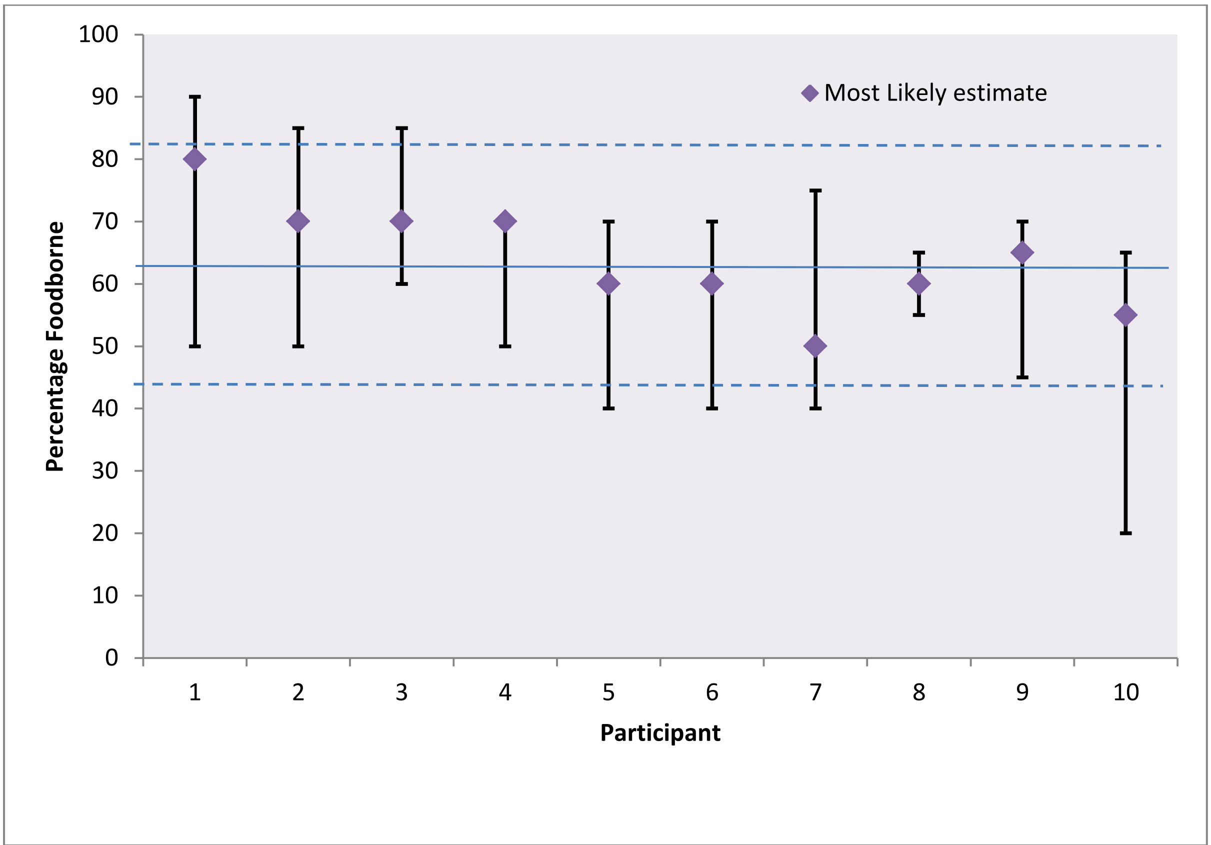
While the elicitation questionnaire was administered on two occasions, results in the following sections relate only to the output from the second questionnaire. At the time of administration of the second questionnaire, participants were provided with the results of their first round questionnaire and were given the option of amending the first round questionnaire or completing a fresh questionnaire. The majority of participants (80%; 8/10) completed the second round by amending their first round questionnaire.

3.3.1 *Campylobacter*

3.3.1.1 Proportion foodborne

Figure 2 summarises the individual estimates of the proportion of cases of *Campylobacter* infection that are due to foodborne transmission.

Figure 2: Individual estimates of the proportion of cases of *Campylobacter* infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

The individual most likely estimates of the proportion of *Campylobacter* infection cases that are due to foodborne transmission fall in a fairly compact range (50-80%). There is considerable variation in the width of the intervals (minimum-maximum) defined by different experts, with the narrowest interval being 10% and the widest 40%.

Table 3 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 3: Summary statistics for the proportion of *Campylobacter* infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	62.6	25.7-89.8	43.4-82.5
Self-assessed expertise	63.8	25.9-89.7	44.1-83.2
Performance-based	61.0	41.9-70.0	49.3-68.8

It is interesting to note that the estimated proportion of *Campylobacter* infection cases that are due to foodborne transmission has increased slightly from the mean estimate of 56.2% derived in 2005(Lake *et al.*, 2010). The large amount of investigative work carried out on *Campylobacter* in the period 2005-2013 is reflected in this pathogen having the highest average self-assessed expertise level of any of the pathogens considered in the current study (mean = 3.9 on a scale from 1 to 5), and the slight increase in foodborne attribution since 2005 may reflect the accumulated evidence supporting poultry as a principal vehicle, despite the approximate 50% reduction in incidence of reported disease. This investigative background may also be responsible for the average interval in the current study (45-74.5%) being narrower than the average interval in the 2005 study (30-80).

3.3.1.2 Ranking of contributions from different transmission routes

Table 4 gives the average rank position for each of five transmission routes for *Campylobacter* infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 4: Average rank position for each of five transmission routes for *Campylobacter* infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	1	3.3	3.3	2.5	4.4
Self-assessed expertise	1	3.3	3.3	2.4	4.5
Performance-based	1	2.6	2.7	3.3	4.7

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5

Expert opinions were highly consistent in identifying food as the highest ranked route of transmission for *Campylobacter* infection. There was less consensus concerning the relative ranking of other transmission routes. Of the remaining four transmission routes, person-to-person transmission was judged less important.

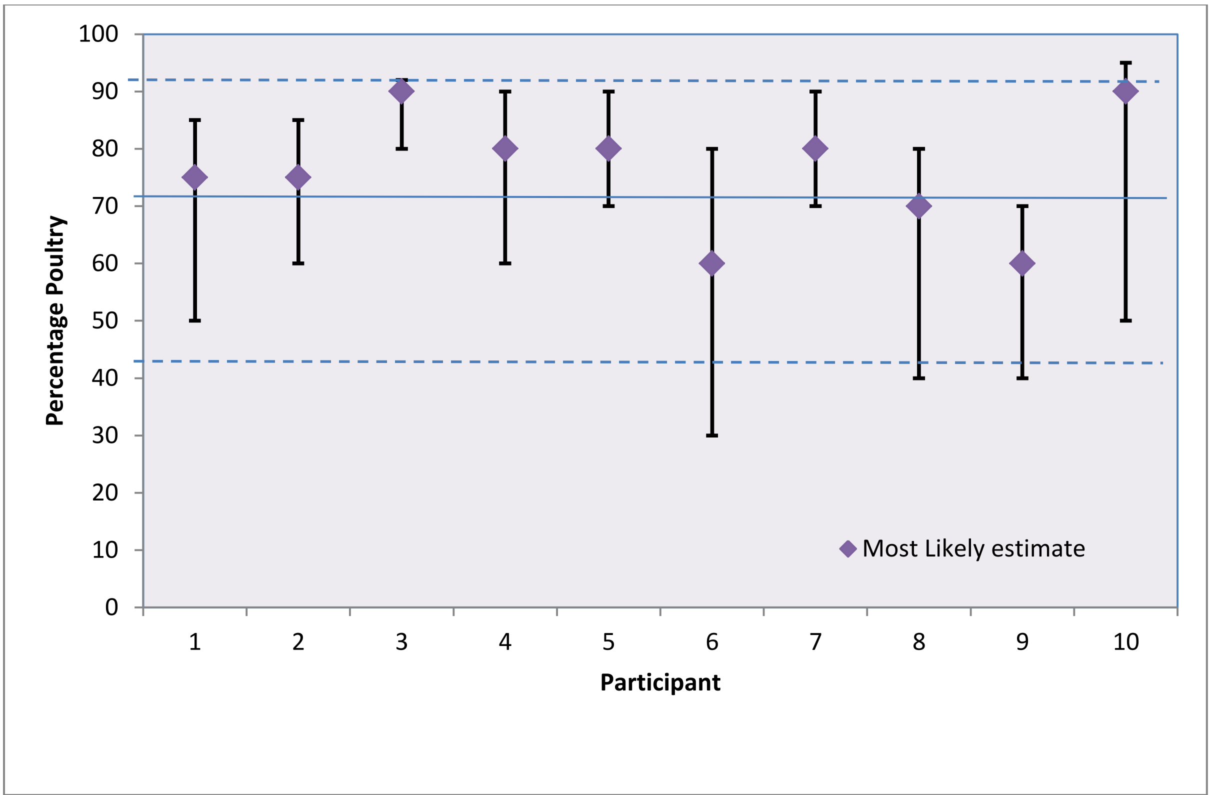
An expert elicitation carried out in the Netherlands produced comparable results for *Campylobacter* infection, with food judged to be the primary transmission route and person-to-person transmission contributing the least of the transmission routes considered (Havelaar *et al.*, 2008). The environment and animal contact were judged to contribute similar fractions of the total burden of *Campylobacter* infections, although the environment was defined to include drinking water in the Dutch study.

3.3.1.3 Proportion of foodborne Campylobacter infection due to specific foods

Poultry

Figure 3 summarises the individual estimates of the proportion of foodborne cases of *Campylobacter* infection that are due to poultry. It should be noted that poultry includes poultry offals, but not contamination of shell eggs.

Figure 3: Individual estimates of the proportion of foodborne cases of *Campylobacter* infection due to poultry



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Table 5 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 5: Summary statistics for the proportion of foodborne *Campylobacter* infection cases due to poultry, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	74.1	31.3-94.9	49.0-91.2
Self-assessed expertise	75.4	34.0-94.9	51.6-91.2
Performance-based	62.9	31.6-89.7	45.8-84.7

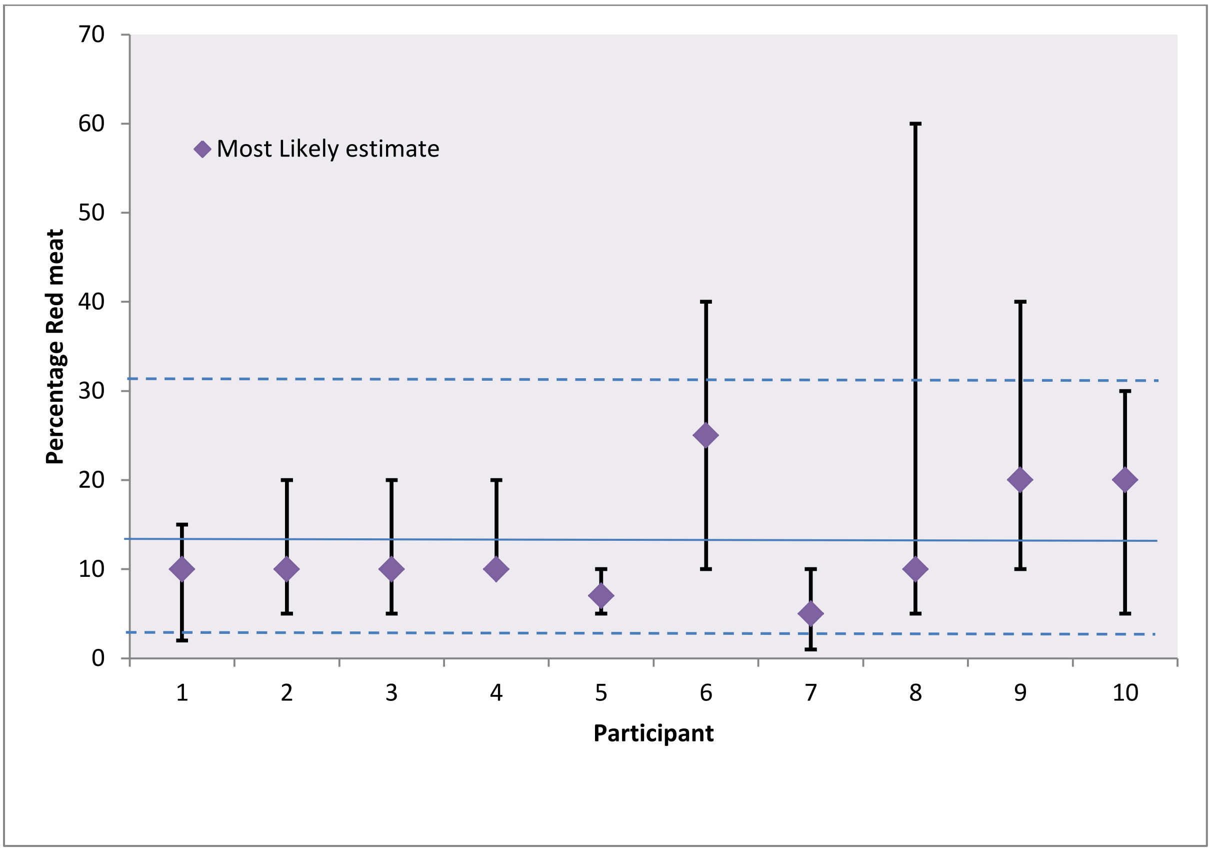
It is interesting to note that, although the recent significant decreases in notifications of *Campylobacter* infection in New Zealand have been attributed to improvements in the poultry industry (French and Marshall, 2009; 2010), the expert panel estimated that the contribution of poultry to foodborne *Campylobacter* infection was greater in 2012 (Table 4; 75%) than in 2005 (53%) (Cressey and Lake, 2005).

Studies in the Netherlands (Havelaar *et al.*, 2008), Canada (Davidson *et al.*, 2011) and the United States (Hoffmann *et al.*, 2006) used expert elicitation to estimate that poultry, on average, accounted for 59, 54 and 72% of foodborne *Campylobacter* infections, respectively.

Red Meat

Figure 4 summarises the individual estimates of the proportion of foodborne cases of *Campylobacter* infection that are due to red meat. It should be noted that red meat includes red meat offals.

Figure 4: Individual estimates of the proportion of foodborne cases of *Campylobacter* infection due to red meat



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Table 6 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 6: Summary statistics for the proportion of foodborne *Campylobacter* infection cases due to red meat, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	13.8	1.4-50.1	3.8-31.4
Self-assessed expertise	12.7	1.1-54.0	3.9-30.6
Performance-based	19.1	5.1-39.2	6.0-33.4

Other studies have used different categories of food to obtain attribution information. A Dutch study estimated that beef and lamb accounted for 4% of foodborne *Campylobacter* infection cases, while pork accounted for 5%, on average (Havelaar *et al.*, 2008). A Canadian study estimated a mean contribution from beef of 7.5%, game 1.8%, luncheon meat 1.4% and pork 4.7% (Davidson *et al.*, 2011). This gives a total of 15.4% of foodborne *Campylobacter* infection cases due to red meat or red meat products. A US study attributed 4.4% of foodborne *Campylobacter* infections to beef (Hoffmann *et al.*, 2006).

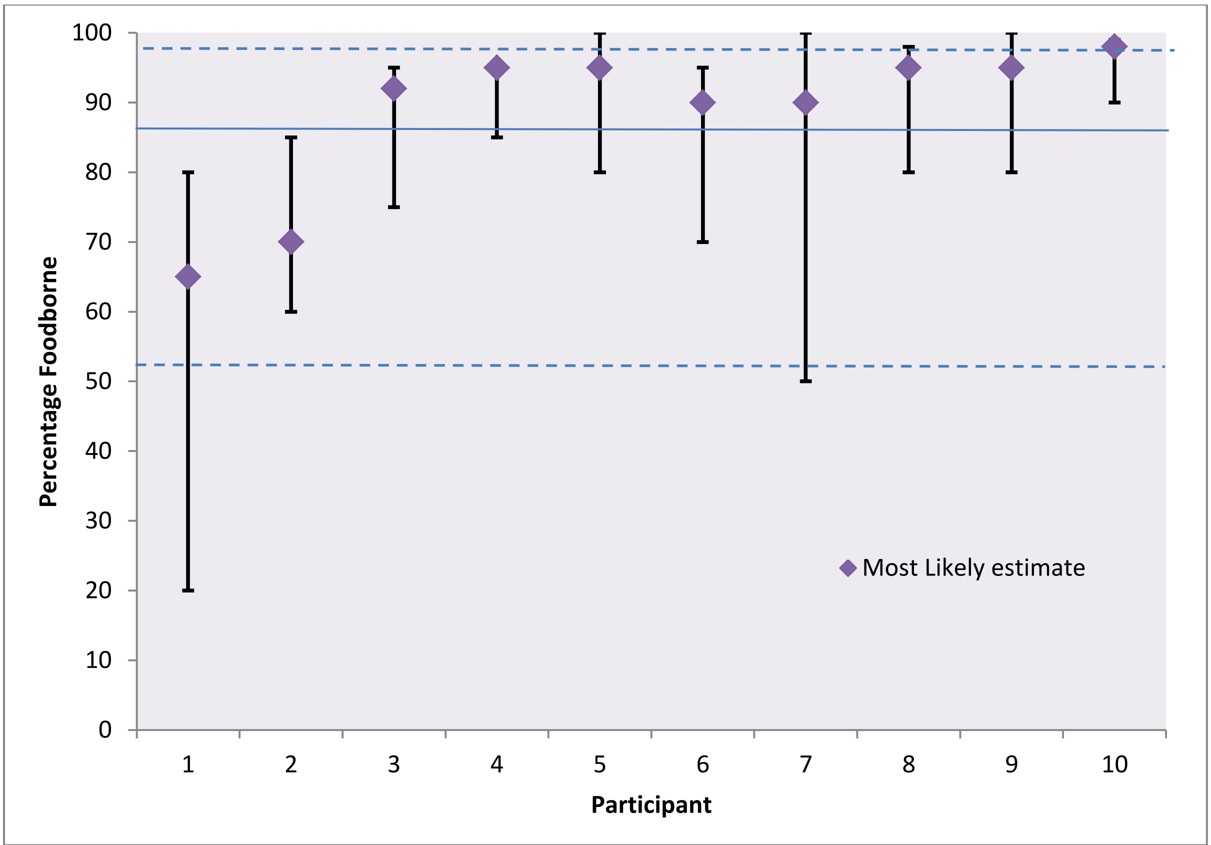
A New Zealand study based on exposure assessment estimated that in 2008 red meat and offal represented 1.5% of the attributable notifications of campylobacteriosis (Lake *et al.*, 2011).

3.3.2 Listeria monocytogenes

3.3.2.1 Proportion foodborne

Figure 5 summarises the individual estimates of the proportion of cases of *Listeria monocytogenes* infection that are due to foodborne transmission. It should be noted that this analysis applies only to the invasive form of infection.

Figure 5: Individual estimates of the proportion of cases of *Listeria monocytogenes* infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

The majority of the individual most likely estimates of the proportion of *Listeria monocytogenes* infection cases that are due to foodborne transmission fall in a very compact range (90-98%). There is considerable variation in the width of the intervals (minimum-maximum) defined by different experts, with the narrowest interval being 9% and the widest 60%.

Table 7 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 7: Summary statistics for the proportion of *Listeria monocytogenes* infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	86.3	28.8-99.9	52.8-98.5
Self-assessed expertise	87.8	24.1-99.9	57.9-98.5
Performance-based	92.5	73.3-100.0	83.2-98.9

Mean estimates of the proportion of *Listeria monocytogenes* infection cases that are due to foodborne transmission are very similar to the mean estimate from the previous survey (85.0%)(Lake *et al.*, 2010).

3.3.2.2 Ranking of contributions from different transmission routes

Table 8 gives the average rank position for each of five transmission routes for *Listeria monocytogenes* infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 8: Average rank position for each of five transmission routes for *Listeria monocytogenes* infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	1	3.9	2.4	2.8	3.2
Self-assessed expertise	1	3.9	2.4	3.0	3.2
Performance-based	1	4.2	3.3	2.2	2.9

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5

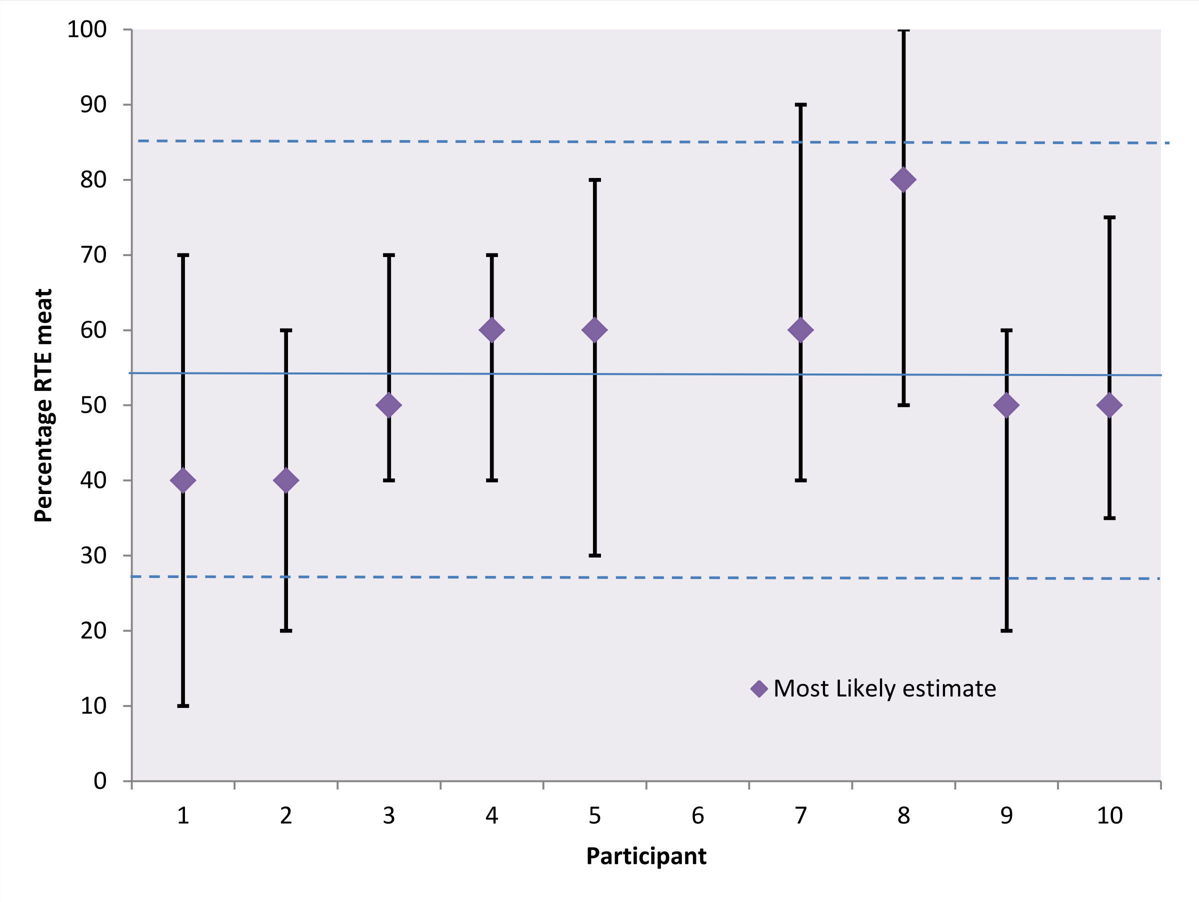
The rankings summarised in Table 7 present a similar picture to a study carried out in the Netherlands (Havelaar *et al.*, 2008), in which food was the dominant transmission route.

3.3.2.3 Proportion of foodborne Listeria monocytogenes infection due to specific foods

Ready-to-eat (RTE) meat

Figure 6 summarises the individual estimates of the proportion of foodborne cases of *Listeria monocytogenes* infection that are due to RTE meat.

Figure 6: Individual estimates of the proportion of foodborne cases of *Listeria monocytogenes* infection due to RTE meat



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Table 9 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 9: Summary statistics for the proportion of foodborne *Listeria monocytogenes* infection cases due to RTE meat, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	54.1	11.7-98.4	27.7-86.2
Self-assessed expertise	55.2	12.6-99.4	29.9-87.7
Performance-based	49.6	23.3-79.6	32.2-70.7

The results summarised in Table 8 are consistent with results from the earlier New Zealand expert elicitation, in which it was judged that, on average, 53.9% of foodborne *Listeria monocytogenes* infections were due RTE meats.

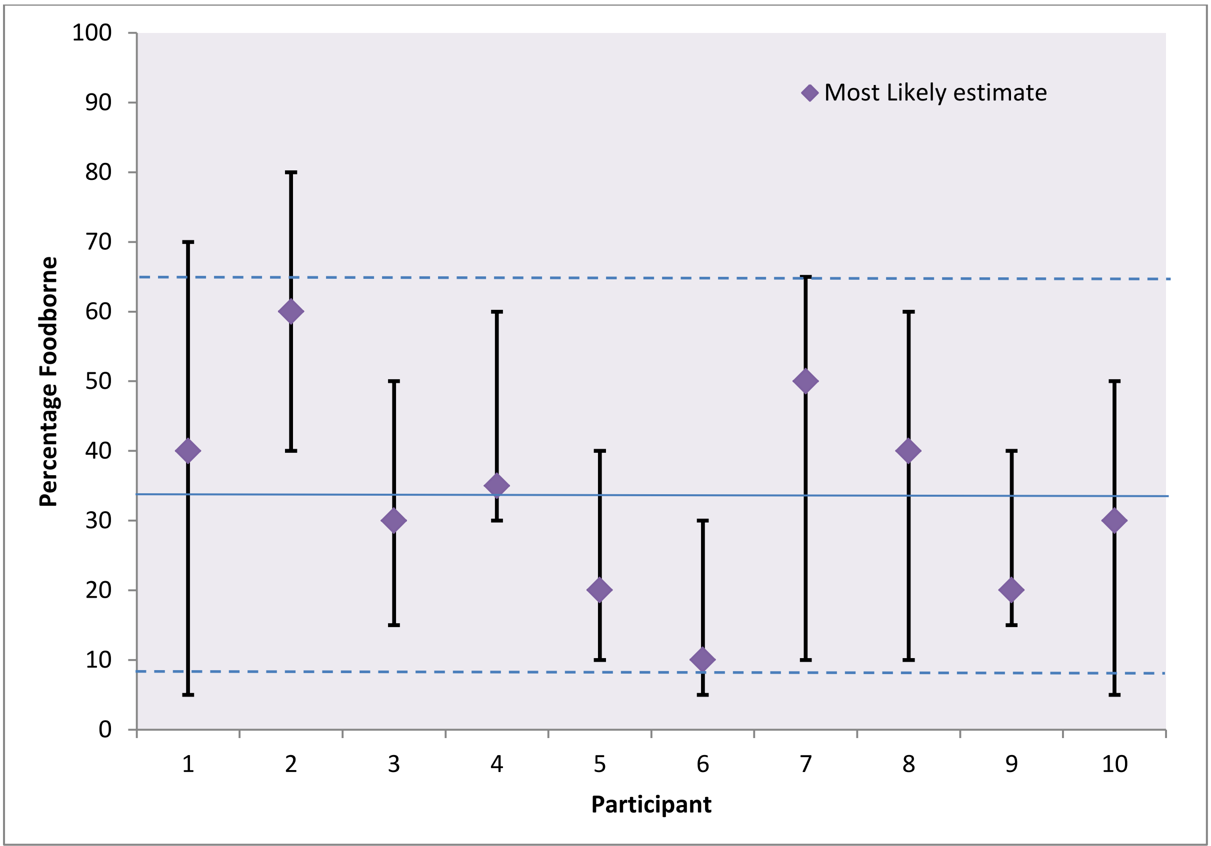
A Canadian expert elicitation estimated that 51% of foodborne *Listeria monocytogenes* infections could be attributed to 'luncheon meat' (Davidson *et al.*, 2011). This was the only food descriptor used in their study that was similar in scope to RTE meat. An US study gave similar results with 54% of foodborne *Listeria monocytogenes* infections estimated to be due to 'lunch meat' (Hoffmann *et al.*, 2006).

3.3.3 Norovirus

3.3.3.1 Proportion foodborne

Figure 7 summarises the individual estimates of the proportion of cases of norovirus infection that are due to foodborne transmission.

Figure 7: Individual estimates of the proportion of cases of norovirus infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

There is quite a diversity of opinions with respect to the contribution of food to norovirus infections, with most likely estimates ranging from 10 to 60%. There is also considerable uncertainty about some individual estimates, with minimum to maximum intervals as wide as 65%.

Table 10 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 10: Summary statistics for the proportion of norovirus infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	33.8	5.0-77.1	9.1-65.7
Self-assessed expertise	32.7	5.1-78.7	10.0-66.4
Performance-based	20.9	5.1-38.7	8.4-32.0

The mean estimates of the proportion of norovirus infection cases due to foodborne transmission are only marginally lower than estimates made in the earlier New Zealand expert elicitation (mean = 39.2%) (Lake *et al.*, 2010). On average, the intervals defined around the most likely estimates are wider in the current study (14.5-54.5%) than the earlier study (27.9-48.9%).

3.3.3.2 Ranking of contributions from different transmission routes

Table 11 gives the average rank position for each of five transmission routes for norovirus infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 11: Average rank position for each of five transmission routes for norovirus infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	2.3	3.3	3	4.9	1.1
Self-assessed expertise	2.3	3.4	2.9	4.9	1.2
Performance-based	2.3	3.3	3.1	5	1.2

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5

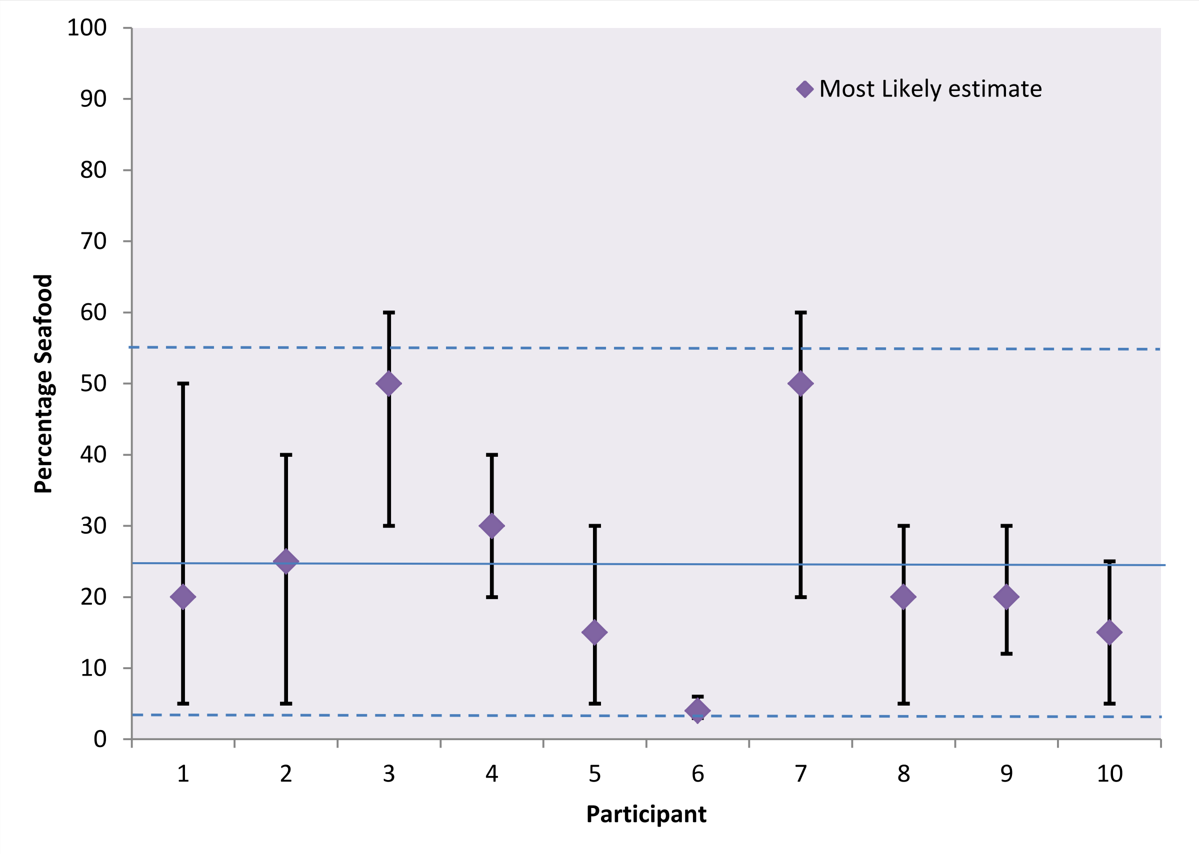
The results summarised in Table 10 show a clear, but not unanimous, opinion that norovirus infection is primarily transmitted by person-to-person contact. This is consistent with the results of a Dutch transmission route attribution exercise that concluded that, in order of decreasing contribution, the ranking of pathways was person-to-person, food, environment and animal contact (Havelaar *et al.*, 2008).

3.3.3.3 Proportion of foodborne norovirus infection due to specific foods

Seafood

Figure 8 summarises the individual estimates of the proportion of foodborne cases of norovirus infection that are due to seafood.

Figure 8: **Individual estimates of the proportion of foodborne cases of norovirus infection due to seafood**



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Table 12 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 12: **Summary statistics for the proportion of foodborne norovirus infection cases due to seafood, by simulation aggregation**

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	24.6	3.1-59.8	3.7-54.8
Self-assessed expertise	24.4	3.1-59.7	3.9-54.7
Performance-based	17.1	3.0-29.7	3.6-26.5

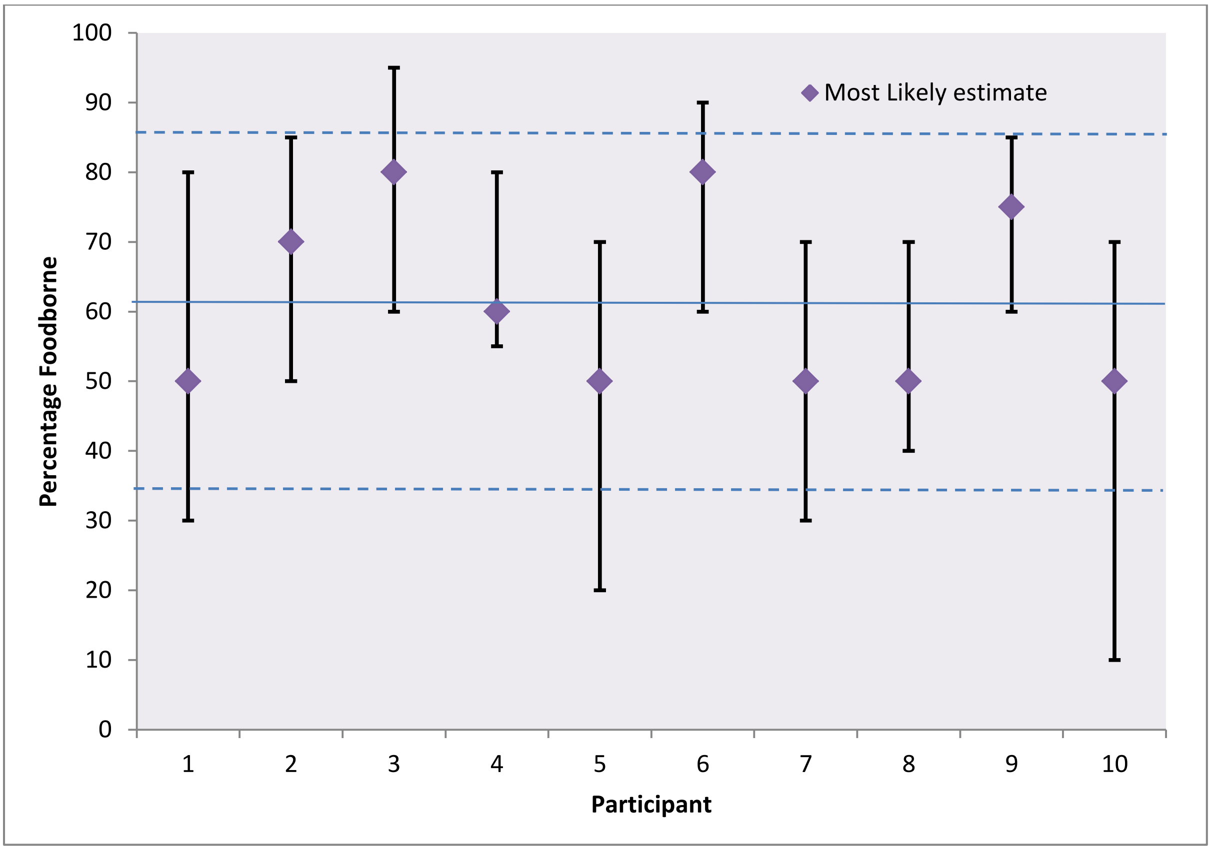
The expert elicitation reported by Havelaar *et al*. (2008) estimated that 16% of foodborne norovirus infection was due to fish and shellfish. Davidson *et al*. (2011) estimated a mean proportion of 34% of foodborne norovirus infection as due to seafood, while an US study arrived at an almost identical estimate (34.1%) (Hoffmann *et al*., 2006). The results from the current study are intermediate between these overseas estimates.

3.3.4 *Salmonella* (non-Typhoidal)

3.3.4.1 Proportion foodborne

Figure 9 summarises the individual estimates of the proportion of cases of *Salmonella* infection that are due to foodborne transmission.

Figure 9: Individual estimates of the proportion of cases of *Salmonella* infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

The panel reported a high level of expertise associated with *Salmonella*, with an average expertise rating of 3.4. There was good consistency between individual most likely estimates, with all estimates in the range 50-80%. However, there was considerable uncertainty associated with some estimates, with some intervals covering a 60% range.

Table 13 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 13: Summary statistics for the proportion of *Salmonella* infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	61.2	15.4-94.3	34.2-86.0
Self-assessed expertise	62.1	18.3-94.4	35.2-86.4
Performance-based	69.2	22.1-89.7	36.5-83.9

The mean values reported in Table 13 are very similar to that from the previous New Zealand study (59.6%) (Lake *et al.*, 2010). On average, the intervals defined by participants are slightly wider (more uncertain) than those from the 2005 study (Cressey and Lake, 2005).

3.3.4.2 Ranking of contributions from different transmission routes

Table 14 gives the average rank position for each of five transmission routes for *Salmonella* infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 14: Average rank position for each of five transmission routes for *Salmonella* infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	1.1	4	3.7	2.2	3.6
Self-assessed expertise	1.1	4	3.6	2.1	3.7
Performance-based	1	4	4.6	2.8	2.6

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5

The ranking information summarised in Table 14 demonstrates near-unanimous agreement between participants that food, followed by animal contact are the primary transmission routes for *Salmonella* infection. The Dutch study, which considered the relative importance of various transmission routes, was in agreement with the current study regarding the importance of foodborne transmission, but concluded that the environment was the second most important transmission route, with animal and person-to-person contact of lower and similar importance (Havelaar *et al.*, 2008).

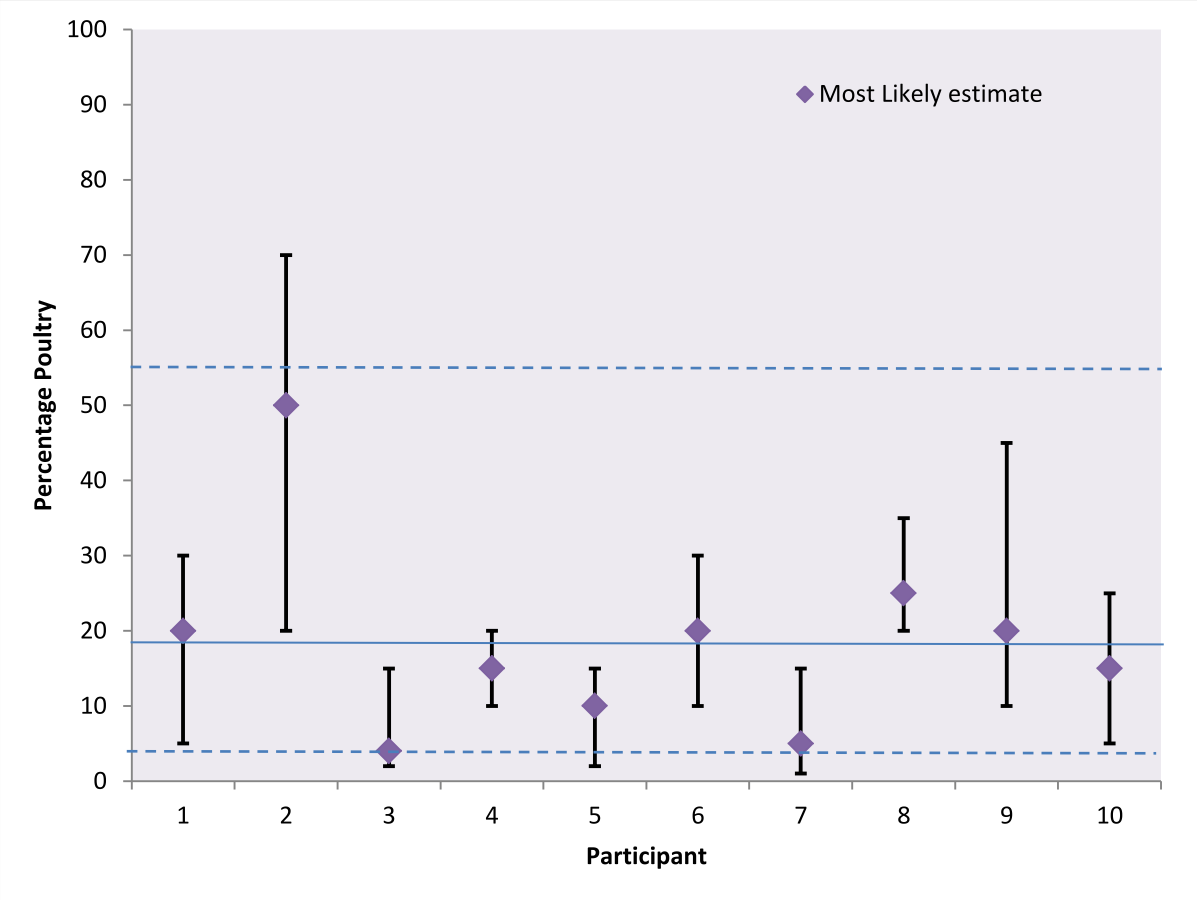
This difference in expert opinion between the two countries is almost certainly related to the New Zealand experience with *Salmonella* Brandenburg and the evidence that this serovar is mainly transmitted to humans by animal contact (Baker *et al.*, 2007).

3.3.4.3 Proportion of foodborne Salmonella infection due to specific foods

Poultry

Figure 10 summarises the individual estimates of the proportion of foodborne cases of *Salmonella* infection that are due to poultry.

Figure 10: Individual estimates of the proportion of foodborne cases of *Salmonella* infection due to poultry



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Table 15 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 15: Summary statistics for the proportion of foodborne *Salmonella* infection cases due to poultry, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	18.7	1.1-67.9	3.1-55.8
Self-assessed expertise	19.2	1.3-67.9	3.0-56.5
Performance-based	19.4	2.8-43.8	6.4-34.6

The mean estimates in Table 15 are considerably lower than the mean estimate from the 2005 New Zealand expert elicitation, when it was estimated that 35.7% of foodborne *Salmonella* infections were due to poultry.

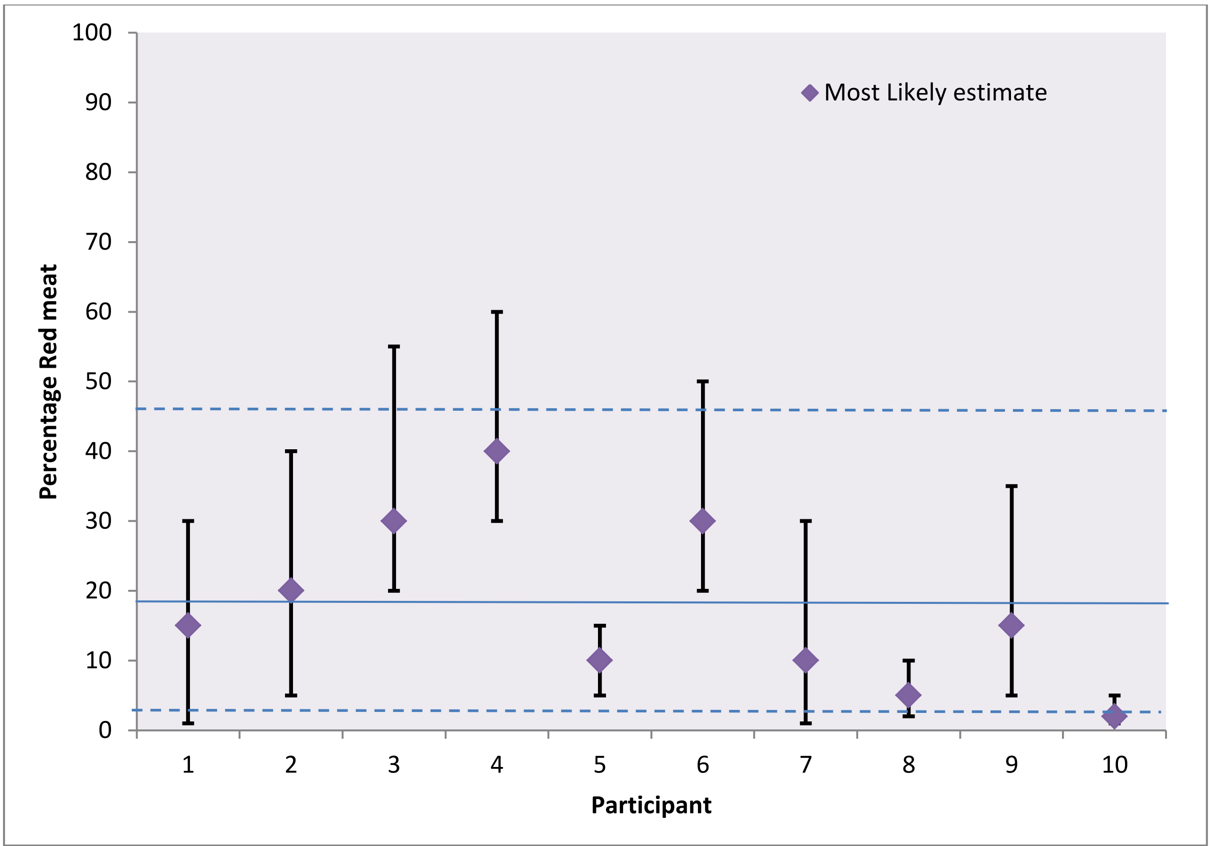
The mean estimates in Table 15 are within the range of similar estimates for other countries. These include 15% of foodborne *Salmonella* infection cases due to poultry in the Netherlands

(Havelaar *et al.*, 2008), 34.2% in Canada (Davidson *et al.*, 2011) and 35.1% in the United States (Hoffmann *et al.*, 2006).

Red meat

Figure 11 summarises the individual estimates of the proportion of foodborne cases of *Salmonella* infection that are due to red meat.

Figure 11: Individual estimates of the proportion of foodborne cases of *Salmonella* infection due to red meat



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Table 16 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 16: Summary statistics for the proportion of foodborne *Salmonella* infection cases due to red meat, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	18.8	1.0-59.1	1.8-46.0
Self-assessed expertise	19.2	1.0-56.2	2.1-46.1
Performance-based	17.3	5.3-48.3	7.1-36.9

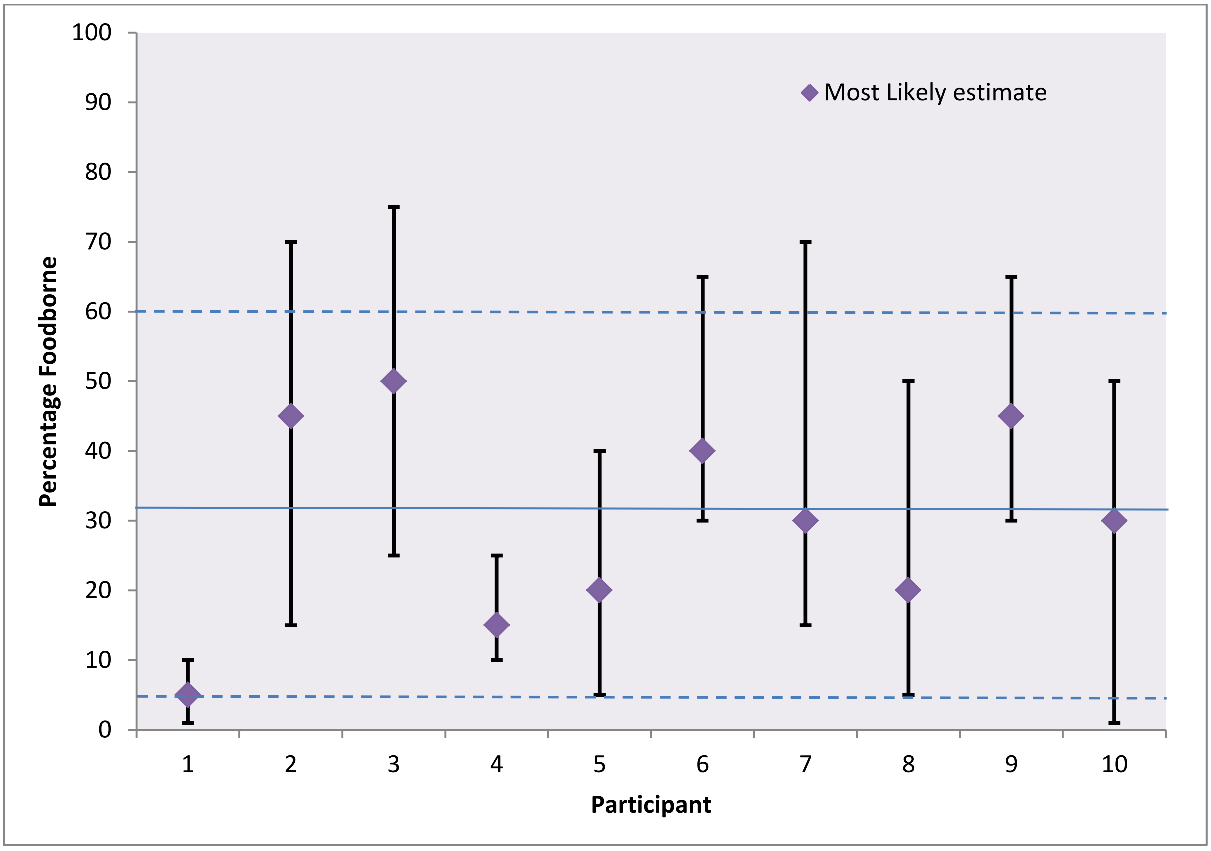
The Dutch expert elicitation concluded that on average 13% of foodborne *Salmonella* infections were due to beef and lamb, while a further 14% were due to pork, giving a total of 27% due to red meat (Havelaar *et al.*, 2008). The US study attributed 10.9% of foodborne *Salmonella* infections to beef and 5.7% to pork (total 16.6%) (Hoffmann *et al.*, 2006). The Canadian expert elicitation attributed 5.8% of foodborne *Salmonella* infections to beef, 1.5% to game, 4.8% to luncheon meat and 7.2% to pork (total 19.3%).

3.3.5 *Escherichia coli* O157 (STEC O157)

3.3.5.1 Proportion foodborne

Figure 12 summarises the individual estimates of the proportion of cases of STEC O157 infection that are due to foodborne transmission.

Figure 12: Individual estimates of the proportion of cases of STEC O157 infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

There is considerable variability in both the most likely estimates (5 to 50%) and the degree of uncertainty, as indicated by the width of defined intervals (9 to 55%).

Table 17 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 17: Summary statistics for the proportion of STEC O157 infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	31.0	1.5-73.5	3.8-60.1
Self-assessed expertise	29.9	1.3-72.9	3.5-60.7
Performance-based	40.1	5.7-64.2	12.7-57.8

The mean estimates of the proportion of STEC O157 infections that are due to foodborne transmission are lower than the equivalent estimate from the 2005 New Zealand study (39.5%)(Lake *et al.*, 2010). It should be noted that the 2005 study considered STEC infections as a single group, while the current study has considered those due to O157 genotypes separately to the non-O157 genotypes.

3.3.5.2 Ranking of contributions from different transmission routes

Table 18 gives the average rank position for each of five transmission routes for STEC O157 infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 18: Average rank position for each of five transmission routes for STEC O157 infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	2	3.5	2.5	1.9	4.2
Self-assessed expertise	2.3	3.5	2.4	1.8	4.3
Performance-based	1.2	3.7	2.3	2.1	5

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5

The ranking results summarised in Table 18 show significant disagreement as to whether food or animal contact is the primary transmission route for STEC O157 infections. However, there is good agreement that person-to-person transmission is the least important transmission route.

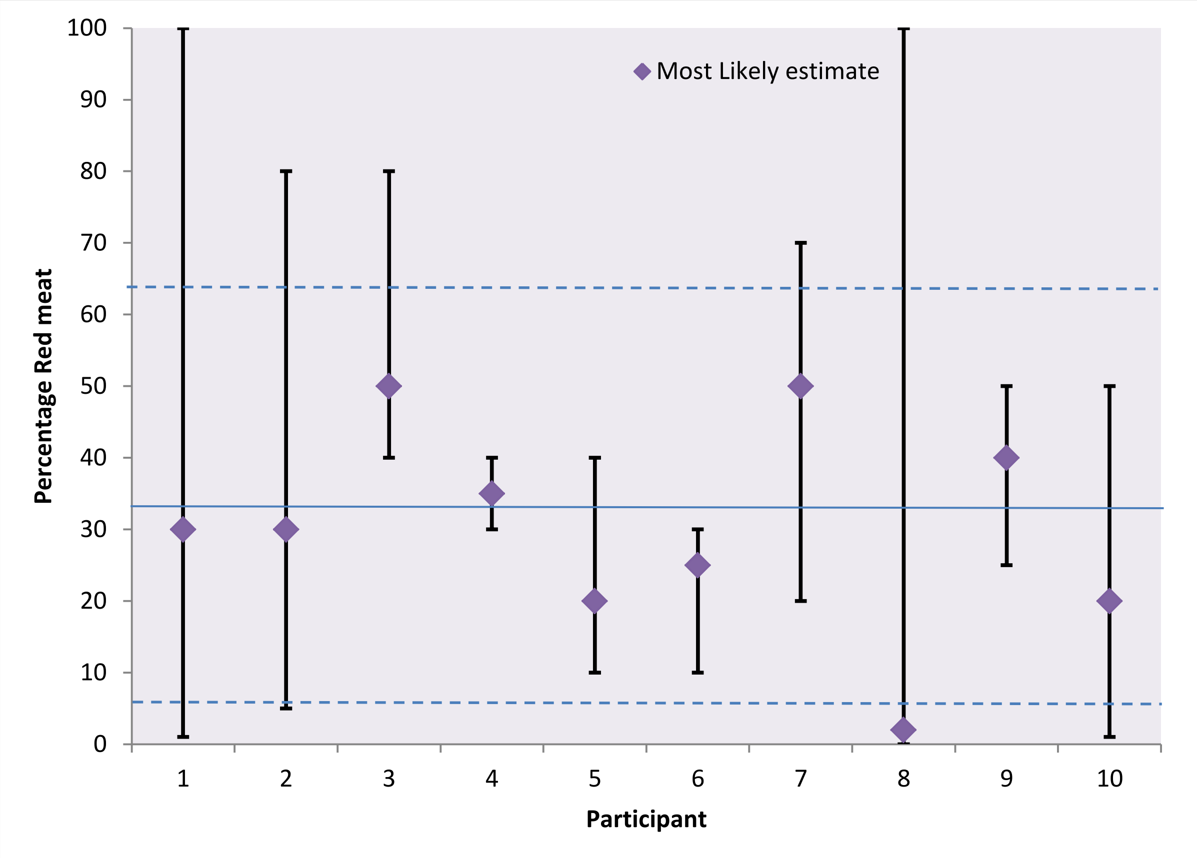
The Dutch expert elicitation concluded that foodborne transmission accounted for approximately twice the proportion of cases as animal contact (Havelaar *et al.*, 2008). It is uncertain whether the difference between the Dutch and current study reflect true difference in the aetiology of the disease in the two countries.

3.3.5.3 Proportion of foodborne STEC O157 infection due to specific foods

Red meat

Figure 13 summarises the individual estimates of the proportion of foodborne cases of STEC O157 infection that are due to red meat.

Figure 13: Individual estimates of the proportion of foodborne cases of STEC O157 infection due to red meat



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Table 19 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 19: Summary statistics for the proportion of foodborne STEC O157 infection cases due to red meat, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	33.2	0.0-91.3	5.6-63.9
Self-assessed expertise	33.5	0.0-90.5	4.4-64.6
Performance-based	33.3	10.7-49.6	14.8-46.9

The 2005 New Zealand expert elicitation estimated that 30.6% of foodborne STEC infections were due to red meat.

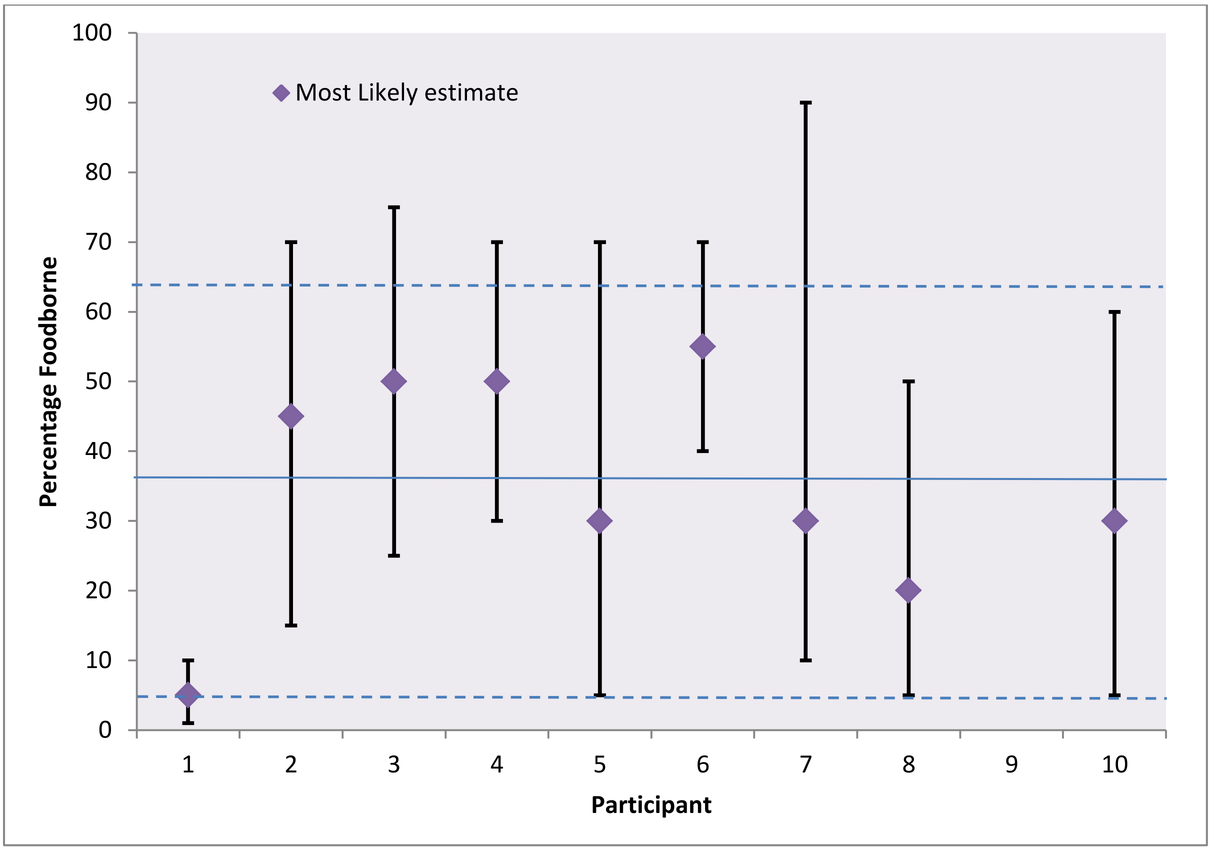
All overseas studies used as comparison points attributed a higher proportion of foodborne STEC infections to red meat, ranging from 50% (beef and lamb 44%, pork 6%) in the Netherlands (Havelaar *et al.*, 2008) to 60.3% (beef 54%, game 2.6%, luncheon meat 2.3%, pork 1.4%) in Canada (Davidson *et al.*, 2011) and 67.9% (beef only) in the United States (Hoffmann *et al.*, 2006).

3.3.6 Non-O157 Shiga toxin-producing *Escherichia coli* O157 (non-O157 STEC)

3.3.6.1 Proportion foodborne

Figure 14 summarises the individual estimates of the proportion of cases of non-O157 STEC infection that are due to foodborne transmission.

Figure 14: Individual estimates of the proportion of cases of non-O157 STEC infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

There is considerable variability in both the most likely estimates (5 to 55%) and the degree of uncertainty, as indicated by the width of defined intervals (9 to 80%).

Table 20 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 20: Summary statistics for the proportion of non-O157 STEC infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	36.4	1.3-80.8	3.8-64.0
Self-assessed expertise	34.0	1.2-77.1	3.5-63.5
Performance-based	41.4	5.4-68.8	13.1-63.8

The mean estimates of the proportion of non-O157 STEC infections that are due to foodborne transmission in Table 20 are slightly higher than the estimates for STEC O157 infections. However, the differences are small and it appears likely that participants view the epidemiology of disease due to the two groups of organisms as being quite similar.

3.3.6.2 Ranking of contributions from different transmission routes

Table 21 gives the average rank position for each of five transmission routes for non- O157 STEC infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 21: Average rank position for each of five transmission routes for non-O157 STEC infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	2.1	3.6	3	1.8	3.7
Self-assessed expertise	2.5	3.3	3.1	1.6	3.8
Performance-based	1.6	4.4	3	2.2	3.8

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5.

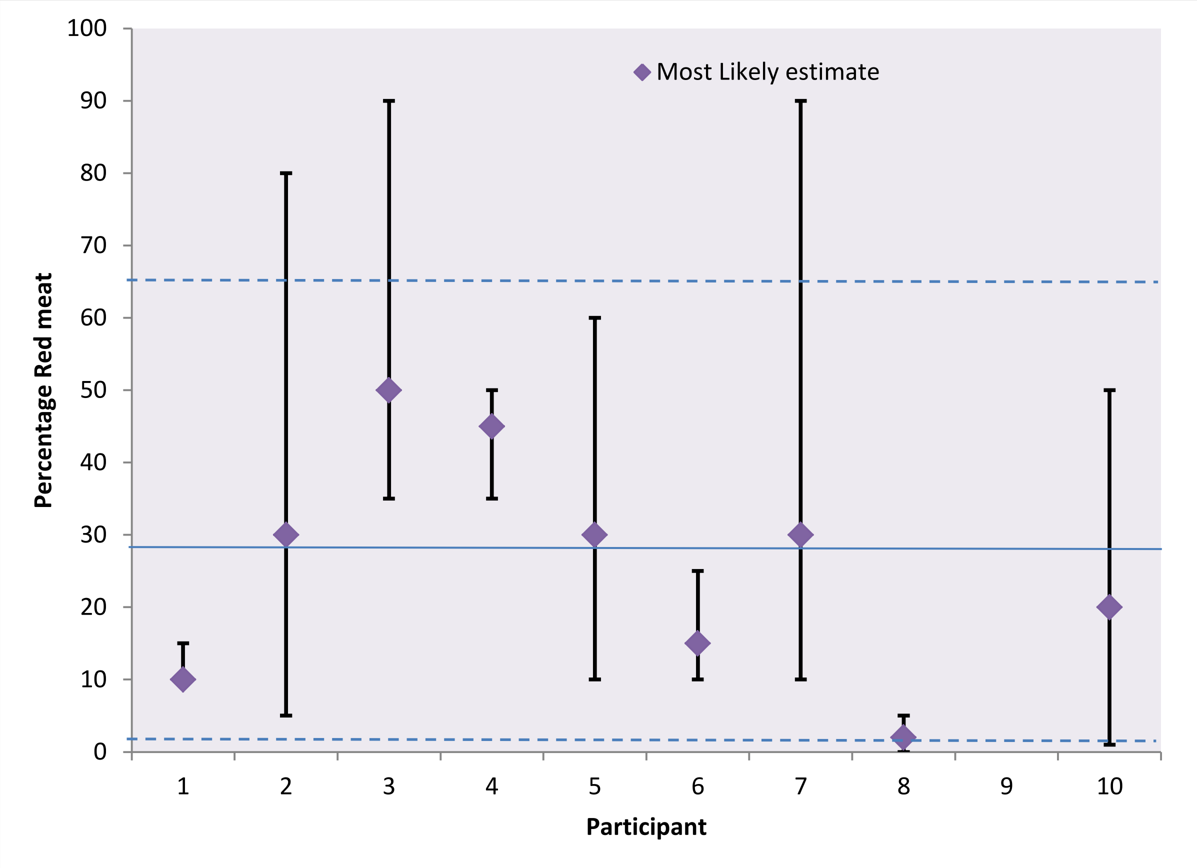
The judgements summarised in Table 21 indicate that the majority of the expert panel believe that animal contact is a greater contributor to non-O157 STEC infections than foodborne transmission. The Dutch expert elicitation arrived at the opposite conclusion, with 42% of non-O157 STEC infections attributed to foodborne transmission and 28% attributed to animal contact (Havelaar *et al.*, 2008).

3.3.6.3 Proportion of foodborne non-O157 STEC infection due to specific foods

Red meat

Figure 13 summarises the individual estimates of the proportion of foodborne cases of non-O157 STEC infection that are due to red meat.

Figure 15: Individual estimates of the proportion of foodborne cases of non-O157 STEC infection due to red meat



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

While participants agreed that 50% or less of foodborne non-O157 STEC infections were due to red meat, there was considerable uncertainty in a number of the judgements.

Table 21 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 22: Summary statistics for the proportion of foodborne non-O157 STEC infection cases due to red meat, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	27.9	0.1-84.1	1.4-64.5
Self-assessed expertise	27.1	0.2-84.6	1.2-65.9
Performance-based	25.5	10.2-58.1	11.9-48.6

The estimates of the proportion of foodborne non-O157 STEC infections due to red meat are slightly lower than the equivalent estimates for STEC O157.

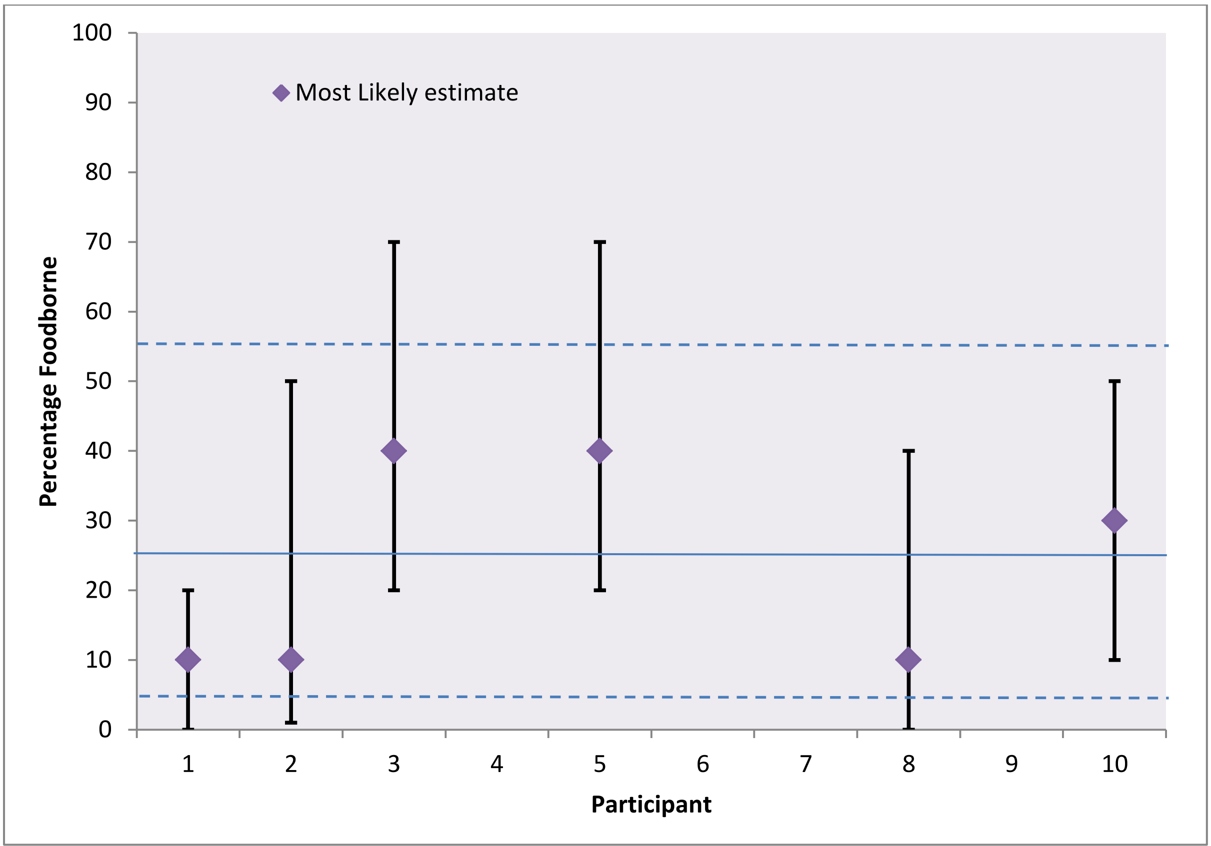
The study of Havelaar *et al*. (2008) concluded that 71% (beef 62%, pork 9%) of foodborne non-O157 STEC infections were due to red meat. It is uncertain whether the differences between the Dutch and New Zealand estimates represent true differences in the aetiology of the disease.

3.3.7 *Toxoplasma gondii*

3.3.7.1 Proportion foodborne

Figure 16 summarises the individual estimates of the proportion of cases of *Toxoplasma gondii* infection that are due to foodborne transmission.

Figure 16: Individual estimates of the proportion of cases of *Toxoplasma gondii* infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

It should be noted that only 6 of 10 participants provided opinions related to *Toxoplasma gondii* and this pathogen had the low average expertise score (1.4) of any of the pathogens considered.

Table 23 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 23: Summary statistics for the proportion of *Toxoplasma gondii* infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	25.3	0.2-67.7	3.6-55.6
Self-assessed expertise	27.6	0.3-67.2	3.8-57.1
Performance-based[1]	41.7	20.4-68.2	25.2-60.2

[1] Only one calibrated participant provided an opinion for this pathogen

The mean estimates in Table 23 using uniform or self-assessed weighting are slightly lower than the corresponding estimate from the 2005 expert elicitation (31.5%), while the mean estimate using performance-based weights was higher than the 2005 estimate (Cressey and Lake, 2005).

3.3.7.2 Ranking of contributions from different transmission routes

Table 24 gives the average rank position for each of five transmission routes for *Toxoplasma gondii* infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 24: Average rank position for each of five transmission routes for *Toxoplasma gondii* infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	2	4	2	1.8	4.7
Self-assessed expertise	1.9	4.1	2.1	1.9	4.6
Performance-based	1	5	3	2	4

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5.

While there is clearly strong belief that water and person-to-person transmission are minor contributors to *Toxoplasma gondii* infections, there appears to be no clear consensus as to relative importance of food, environment and animal contact.

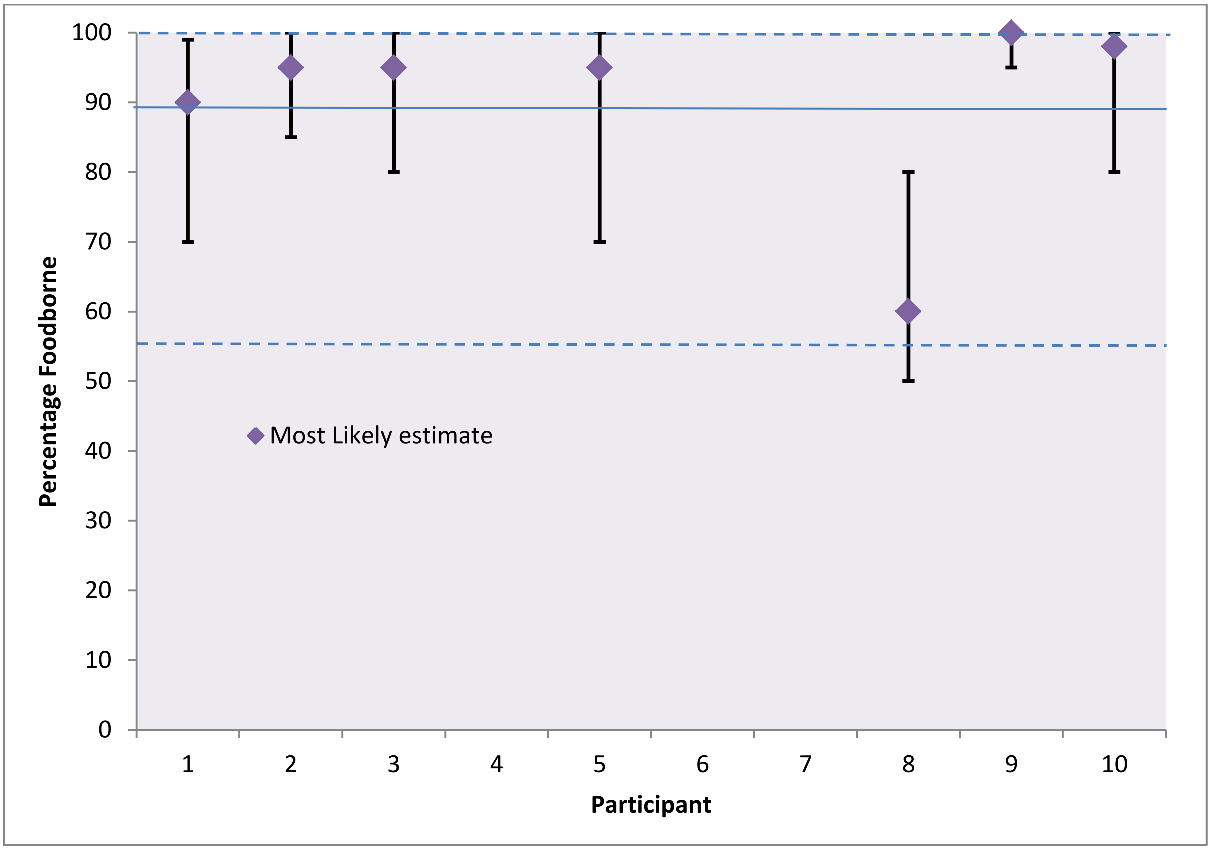
The Dutch expert elicitation concluded that majority of transmission (56%) was foodborne, followed by the environment (36%), with minor contributions from animal and person-to-person contact (Havelaar *et al.*, 2008).

3.3.8 *Vibrio parahaemolyticus*

3.3.8.1 *Proportion foodborne*

Figure 17 summarises the individual estimates of the proportion of cases of *Vibrio parahaemolyticus* infection that are due to foodborne transmission.

Figure 17: Individual estimates of the proportion of cases of *Vibrio parahaemolyticus* infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

While three participants chose not to provide opinions concerning transmission of *Vibrio parahaemolyticus*, all but one of the remaining participants were in agreement that transmission of *Vibrio parahaemolyticus* infection is predominantly (90% or greater) foodborne.

Table 25 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 25: Summary statistics for the proportion of *Vibrio parahaemolyticus* infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	89.0	50.1-100	55.7-99.8
Self-assessed expertise	90.6	50.5-100	56.9-99.9
Performance-based	97.3	74.3-100	84.2-100

The mean estimates of the proportion of *Vibrio parahaemolyticus* infections that are due to foodborne transmission (Table 25) are very similar to the estimate from the 2005 New Zealand expert elicitation (89.2%) (Cressey and Lake, 2005).

3.3.8.2 Ranking of contributions from different transmission routes

Table 25 gives the average rank position for each of five transmission routes for *Vibrio parahaemolyticus* infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 26: Average rank position for each of five transmission routes for *Vibrio parahaemolyticus* infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	1	2.7	2.7	3.4	2.6
Self-assessed expertise	1	2.7	2.7	3.4	2.7
Performance-based	1	2.2	2	2.5	2.7

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5.

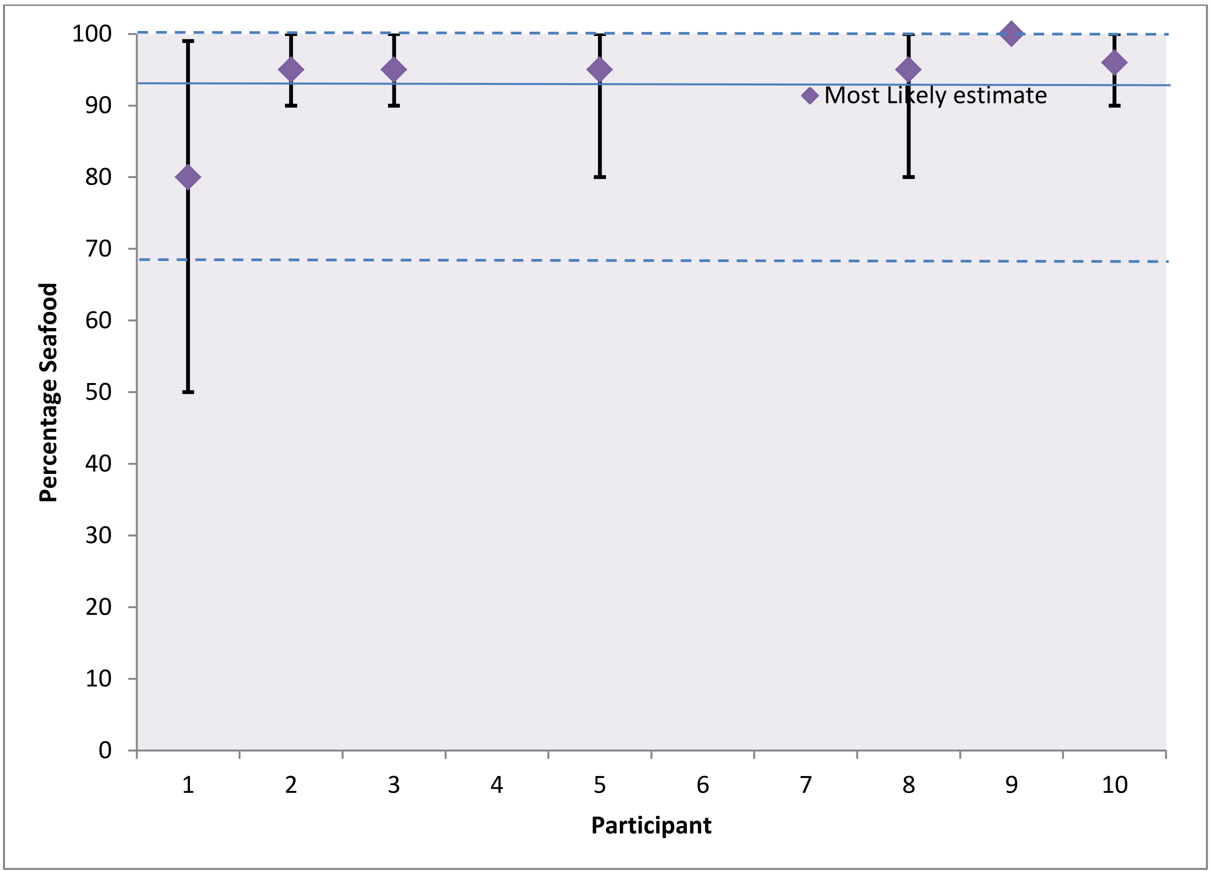
The participants in the expert elicitation were unanimous in identifying food as the primary transmission route for *Vibrio parahaemolyticus* infections. However, there appears to be little consensus on what other transmission route may be important. This is probably not surprising given that the panel judged that approximately 90% of *Vibrio parahaemolyticus* transmission was due to food.

3.3.8.3 Proportion of foodborne Vibrio parahaemolyticus infection due to specific foods

Seafood

Figure 18 summarises the individual estimates of the proportion of foodborne cases of *Vibrio parahaemolyticus* infection that are due to seafood.

Figure 18: Individual estimates of the proportion of foodborne cases of *Vibrio parahaemolyticus* infection due to seafood



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

The participants in the current expert elicitation were in good agreement that seafood was the major contributor to foodborne *Vibrio parahaemolyticus* transmission.

Table 27 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 27: Summary statistics for the proportion of foodborne *Vibrio parahaemolyticus* infection cases due to seafood, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	92.9	54.4-100	68.3-100
Self-assessed expertise	93.8	51.6-100	70.3-100
Performance-based	98.4	81.0-100	88.3-100

The mean estimates in Table 27 are very similar to the corresponding estimate from the 2005 New Zealand expert elicitation (89.2%) (Cressey and Lake, 2005).

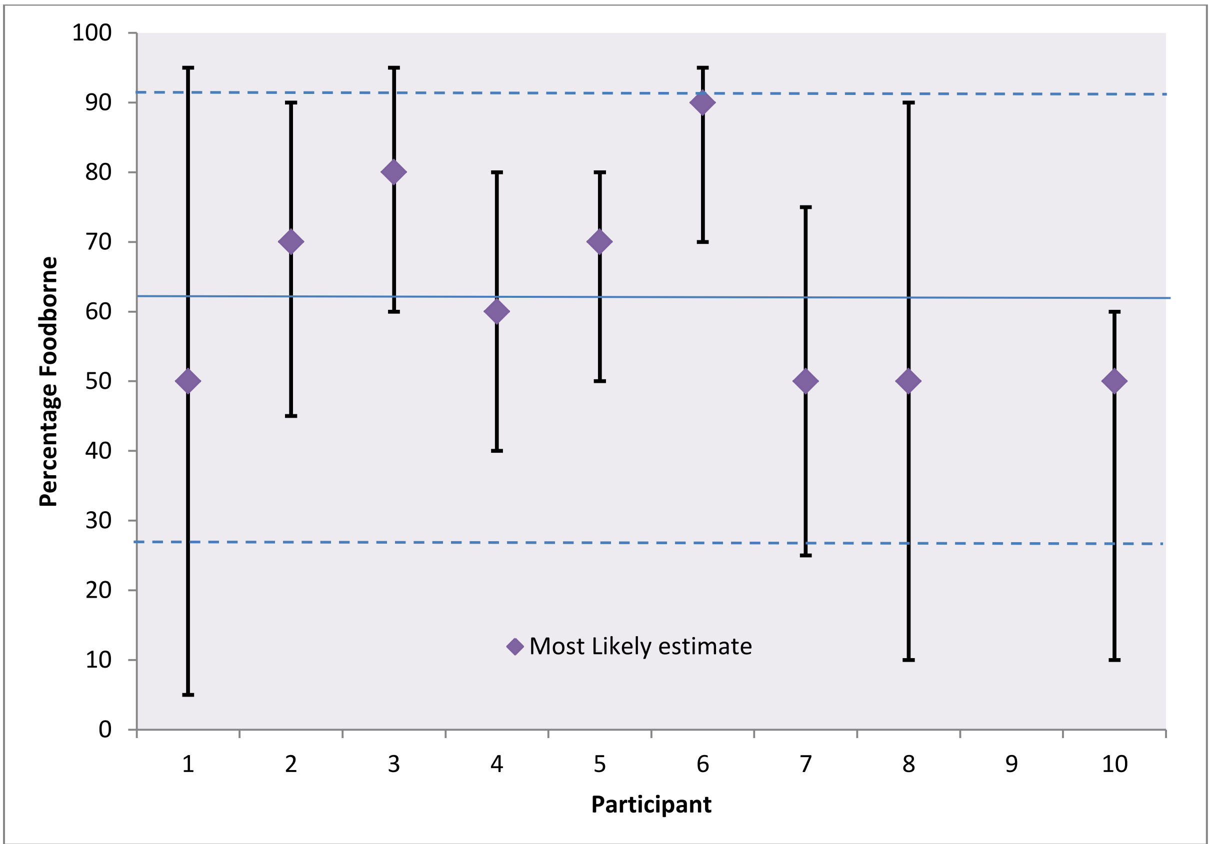
Studies in other countries have considered *Vibrio* spp. as a group, rather than just considering *Vibrio parahaemolyticus*. Estimates of the contribution of seafood to foodborne *Vibrio* infection have been similarly high (Canada 89.4%, US 97.1%) (Davidson *et al.*, 2011; Hoffmann *et al.*, 2006).

3.3.9 *Yersinia enterocolitica*

3.3.9.1 Proportion foodborne

Figure 19 summarises the individual estimates of the proportion of cases of *Yersinia enterocolitica* infection that are due to foodborne transmission.

Figure 19: Individual estimates of the proportion of cases of *Yersinia enterocolitica* infection due to foodborne transmission



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Opinions of the foodborne proportion of *Yersinia enterocolitica* infections are moderately consistent across participants (50-90%), although some judgements are highly uncertain, as assessed by the width of the interval defined.

Table 28 gives summary statistics for the aggregation using uniform weights, self-assessed expertise weights and performance-based weights.

Table 28: Summary statistics for the proportion of *Yersinia enterocolitica* infection cases due to foodborne transmission, by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	62.1	9.3-94.8	27.2-91.4
Self-assessed expertise	63.2	10.3-94.9	29.0-91.5
Performance-based	75.8	50.9-94.9	58.1-93.2

Mean estimates of the proportion of *Yersinia enterocolitica* infections due to foodborne transmission (Table 28) are similar to the estimate from the previous New Zealand expert elicitation (56.2%)(Lake *et al.*, 2010).

3.3.9.2 Ranking of contributions from different transmission routes

Table 29 gives the average rank position for each of five transmission routes for *Yersinia enterocolitica* infection. Averages calculated using self-assessed expertise and performance based weighting are also included.

Table 29: Average rank position for each of five transmission routes for *Yersinia enterocolitica* infection

Weighting	Food	Water	Environment	Animal contact	Person-to-person
Uniform	1	2.4	4.1	2.6	4.3
Self-assessed expertise	1	2.3	4.2	2.6	4.3
Performance-based	1	2	4.6	3	4.4

Note that the averages in this table are average ranks. A low number represents a high ranking, while a high number represents a low ranking. The maximum possible range is 1 to 5.

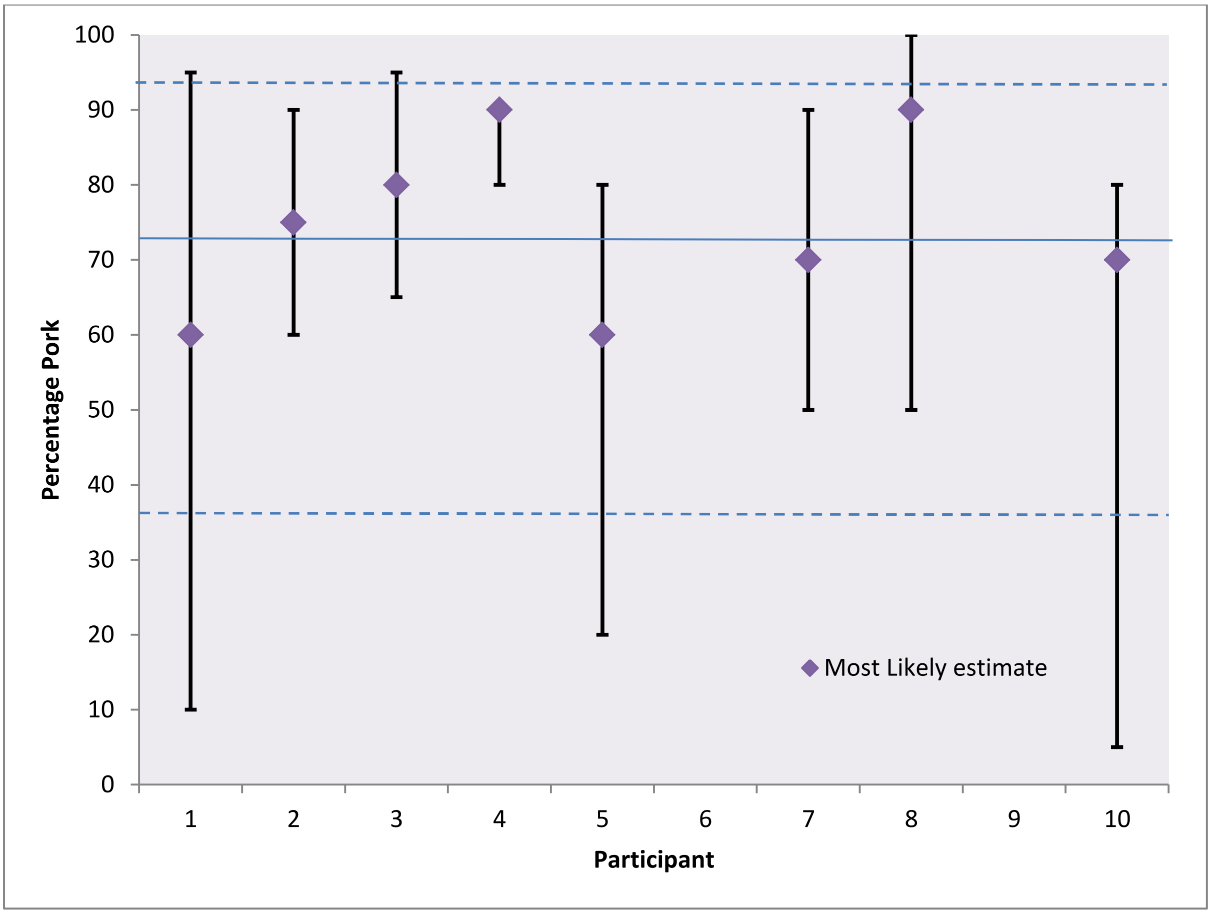
Participants in the current study were unanimous in identifying food as the primary transmission route for *Yersinia enterocolitica* infection. Water and animal contact were considered to approximately equally likely secondary transmission routes.

3.3.9.3 Proportion of foodborne Yersinia enterocolitica infection due to specific foods

Pork

Figure 20 summarises the individual estimates of the proportion of foodborne cases of *Yersinia enterocolitica* infection that are due to pork.

Figure 20: Individual estimates of the proportion of foodborne cases of *Yersinia enterocolitica* infection due to pork



The solid horizontal line is the uniform weighted mean
The dashed horizontal lines are the uniform weighted 2.5th and 97.5th percentiles
Reference lines were derived from uniform weighted aggregation of individual estimates by simulation

Participants were in quite good agreement that pork was likely to be the major contributor to foodborne *Yersinia enterocolitica* infections, with a range of most likely estimates of 60-90%.

Table 30 gives summary statistics for the aggregation of individual opinions using uniform weights, self-assessed expertise weights and performance-based weights.

Table 30: Summary statistics for the proportion of foodborne *Yersinia enterocolitica* infection cases due to pork by simulation aggregation

Weighting	Mean	Range (minimum-maximum)	95th percentile credible interval
Uniform	71.7	12.0-99.9	36.6-93.2
Self-assessed expertise	71.1	16.3-99.4	36.8-93.1
Performance-based[1]	56.7	22.6-79.6	34.0-75.2

[1] Only one calibrated participant provided an opinion

The 2005 New Zealand expert elicitation estimated a lower proportion of *Yersinia enterocolitica* infections as due to pork (52.9%) (Cressey and Lake, 2005). However, the results of the current study are similar to estimates from Canada (63.3%) and the United States (71.6%) of the proportion of foodborne *Yersinia enterocolitica* infections attributable to pork.

3.4 Methodological Comparison to the 2005 New Zealand Study

The current expert elicitation included several methodological changes from the previous exercise in 2005 (Cressey and Lake, 2005).

The size of the expert panel was reduced from 14 in 2005 to 10 in the current study. While it is not possible to quantitatively assess the impact of this change, the elicitation operated smoothly with the panel size selected. Participants were given the option of not providing opinions for pathogens where they felt they did not have sufficient expertise. The minimum panel size for any pathogen was 6 (*Toxoplasma gondii*). In a Dutch study using a similar approach, a panel of 16 participants resulted in as few as two opinions being provided for some pathogens (Havelaar *et al.*, 2008).

The current elicitation included a first round elicitation by e-mail, followed by a face-to-face meeting. The extra time afforded by the e-mail round proved valuable in refining definitions for certain foods and transmission routes, although some further refinement occurred during the face-to-face meeting. The specificity of definitions was considered to be very important by participants.

Two weighting schemes for opinions were investigated during the 2013 expert elicitation. Self-assessed weighting resulted in a similar profile of panel expertise to that reported for similar exercises overseas (Havelaar *et al.*, 2008; Hoffmann *et al.*, 2006). The pathogens for which the highest average expertise levels were expressed were consistent with current and recent New Zealand priorities.

The performance-based weights, derived from a set of seed variables, resulted in overall assessments being heavily weighted toward the opinion of one participant. This is not an unusual outcome for this calibration approach (Cooke and Goossens, 2008; Van der Fels-Klerx *et al.*, 2005; Van der Fels-Klerx *et al.*, 2002). However, questions must persist over the 'transferability' of expertise expressed by seed variables to expertise relating to query variables. Choosing seed variables is a highly subjective process.

In general, there were only minor differences in the results achieved by aggregation of opinions using equal weights and self-assessed expertise weighting. Unsurprisingly, the use of performance weights, resulting in aggregate assessments being based on only three opinions, produced different aggregate opinions for some query variables. These differences included both higher and lower estimates, while for some pathogens the performance-based aggregates were nearly identical to those derived using uniform or self-assessed expertise weightings. It is not possible to verify which weighting scheme results in the 'best' aggregate opinion. However, discarding the opinions of seven of ten experts based on generic questions may lose valuable information available from experts with more specialised knowledge of specific pathogens.

One factor that may have influenced the results is that some of the experts were involved in a recently completed case-control study of STEC infections in New Zealand. This may have contributed to the variability in the most likely estimates for foodborne transmission of *E. coli* O157 and non-O157 STEC. However, this study, and its limitations were discussed during the face to face meeting prior to the experts having the opportunity to revise their estimates for these pathogens.

Mean estimates of the proportion of disease due to specific pathogens that is due to foodborne transmission were generally not markedly different to estimates made in 2005. Similarly, estimates of the proportion of foodborne cases that are due to transmission by particular foods were also similar to earlier estimates. A summary comparison is shown below in Table 31. It should be noted that the proportion of foodborne disease due to a specific food is only included in Table 31 where the specific food was considered in both the 2005 and 2013 studies.

Table 31: Comparison of aggregate opinions from the current study with those from the 2005 New Zealand study

Pathogen	Quantity estimated	Mean aggregate estimate (%), based on weighting scheme (95th percentile credible interval)			Mean aggregate estimate from 2005 study (95th percentile credible interval)
		Uniform	Self-assessed	Performance-based	
Campylobacter	% Foodborne	62.6 (43.4-82.5)	63.8 (44.1-83.2)	61.0 (49.3-68.8)	56.2 (26-82)
Campylobacter	% Poultry	74.1 (49.0-91.2)	75.4 (51.6-91.2)	62.9 (45.8-84.7)	52.9 (14-75)
Listeria monocytogenes	% Foodborne	86.3 (52.8-98.5)	87.8 (57.9-98.5)	92.5 (83.2-98.9)	85.0 (48-100)
Listeria monocytogenes	% RTE Meat	54.1 (27.7-86.2)	55.2 (29.9-87.7)	49.6 (32.2-70.7)	53.9 (16-80)
Norovirus	% Foodborne	33.8 (9.1-65.7)	32.7 (10.0-66.4)	20.9 (8.4-32.0)	39.2 (8-64)
Norovirus	% Seafood	24.6 (3.7-54.8)	24.4 (3.9-54.7)	17.1 (3.6-26.5)	40.0[1] (11-78)
Salmonella	% Foodborne	61.2 (34.2-86.0)	62.1 (35.2-86.4)	69.2 (36.5-83.9)	59.6 (18-83)
Salmonella	% Poultry	18.7 (3.1-55.8)	19.2 (3.0-56.5)	19.4 (6.4-34.6)	35.7 (16-73)
STEC O157	% Foodborne	31.0 (3.8-60.1)	29.9 (3.5-60.7)	40.1 (12.7-57.8)	39.5[2] (6-95)
STEC O157	% Red meat	33.2 (5.6-63.9)	33.5 (4.4-64.6)	33.3 (14.8-46.9)	30.6[2] (3-60)
Non-O157 STEC	% Foodborne	36.4 (3.8-64.0)	34.0 (3.5-63.5)	41.4 (13.1-63.8)	39.5[2] (6-95)
Non-O157 STEC	% Red meat	27.9 (1.4-64.5)	27.1 (1.2-65.9)	25.5 (11.9-48.6)	30.6[2] (3-60)
Toxoplasma gondii	% Foodborne	25.3 (3.6-55.6)	27.6 (3.8-57.1)	41.7 (25.2-60.2)	31.5 (3-82)
Vibrio parahaemolyticus	% Foodborne	89.0 (55.7-99.8)	90.6 (56.9-99.9)	97.3 (84.2-100)	89.2 (64-100)
Vibrio parahaemolyticus	% Seafood	92.9 (68.3-100)	93.8 (70.3-100)	98.4 (88.3-100)	89.2 (57-100)
Yersinia enterocolitica	% Foodborne	62.1 (27.2-91.4)	63.2 (29.0-91.5)	75.8 (58.1-93.2)	56.2 (32-92)
Yersinia enterocolitica	% Pork	71.7 (36.6-93.2)	71.1 (36.8-93.1)	56.7 (34.0-75.2)	52.9 (30-74)

Note that the percentage of transmission attributed to specific foods, is a proportion of the foodborne attribution
[1] Estimate relates to shellfish only
[2] For all STEC genotypes

Changes in estimates may be driven by greater awareness of, or changes to, the epidemiology of the disease. *Campylobacter* infection is the most obvious case where the circumstances of the disease have changed since the 2005 expert elicitation. There has been a marked decrease in the notification rate of campylobacteriosis since 2005, which has been attributed to changes in the poultry food supply (Sears *et al.*, 2011). Despite this, expert opinion was that the current 2012 incidence was more likely to be due to foodborne transmission, and foodborne cases were more likely to be due to transmission by poultry.

3.5 Comparison to International Attribution Studies

Another useful outcome of attribution is the opportunity to benchmark against other countries. Table 32 compares the estimated proportion of cases due to foodborne transmission from the current study to similar estimates from other countries.

Table 32: Comparison of foodborne attribution estimates (%) between countries

Country	New Zealand[1]	Australia	Netherlands	USA	England and Wales
Period	2012	2000	2006	2000-2008	1992-2000
Travel-related cases included	No	NS	Yes	No	No
Reference	Current	(Hall and Kirk, 2005)	(Havelaar *et al.*, 2008)	(Scallan *et al.*, 2011)	(Adak *et al.*, 2002)
Campylobacter	62.6	75	42	80	80
Listeria monocytogenes	86.3	98	69	99	99
Norovirus	33.8	25	17	26	11
Salmonella	61.2	87	55	94	92
STEC O157	31.0	65	40	68	63
Non-O157 STEC	36.4	NS	42	82	63
Toxoplasma gondii	25.3	NS	56	50	NS
Vibrio parahaemolyticus	89.0	71	NS	86	NS
Yersinia enterocolitica	62.1	75	NS	90	90

[1] Current study. Uniform weighted estimates have been used for this comparison
NS – not stated or not included in the study

It is not possible to say whether the difference in attribution estimates in Table 32 are due to true differences in disease epidemiology between countries, differences in expert knowledge, differences in elicitation study design or a combination.

4 REFERENCES

Adak GK, Long SM, O'Brien SJ. (2002) Trends in indigenous foodborne disease and deaths, England and Wales: 1992 to 2000. Gut; 51(6): 832-841.

Baker MG, Thornley CN, Lopez LD, Garrett NK, Nicol CM. (2007) A recurring salmonellosis epidemic in New Zealand linked to contact with sheep. Epidemiology and Infection; 135(1): 76-83.

Cooke RM, Goossens LHJ. (2000) Procedures guide for structured expert judgement in accident consequence modelling. Radiation Protection Dosimetry; 90(3): 303-309.

Cooke RM, Goossens LLHJ. (2008) TU Delft expert judgment data base. Reliability Engineering & System Safety; 93(5): 657-674.

Cressey P, Lake R. (2005) Ranking food safety risks. Development of NZFSA policy 2004-2005. ESR Client Report FW0563. Christchurch: ESR.

Cressey P, Lake R. (2011) Estimated incidence of foodborne illness in New Zealand: Application of overseas models and multipliers. ESR Client Report FW11006. Christchurch: ESR.

Cressey P, Lake R. (2012) Discussion document on revised approaches to expert elicitation in a New Zealand context. ESR Client Report FW12001. Christchurch: ESR.

Davidson VJ, Ravel A, Nguyen TN, Fazil A, Ruzante JM. (2011) Food-specific attribution of selected gastrointestinal illnesses: Estimates from a Canadian expert elicitation survey. Foodborne Pathogens and Disease; 8(9): 983-995.

French N, Marshall J. (2009) Dynamic modelling of *Campylobacter* sources in the Manawatu. Final Report: 11178. Palmerston North: Hopkirk Institute, Massey University.

French N, Marshall J. (2010) Source attribution July 2009 to June 2010 of human *Campylobacter jejuni* cases from the Manawatu. Report: 11424. Palmerston North: Hopkirk Institute, Massey University.

Gallagher E, Ryan J, Kelly L, Leforban Y, Wooldridge M. (2002) Estimating the risk of importation of foot-and-mouth disease into Europe. The Veterinary Record; 150: 769-772.

Hall G, Kirk M. (2005) Foodborne illness in Australia. Annual incidence circa 2000. Canberra: Australian Government Department of Health and Ageing.

Havelaar AH, Galindo AV, Kurowicka D, Cooke RM. (2008) Attribution of foodborne pathogens using structured expert elicitation. Foodborne Pathogens and Disease; 5(5): 649-659.

Helmer O. (1967) Analysis of the future. The Delphi method. Accessed at: http://www.rand.org/content/dam/rand/pubs/papers/2008/P3558.pdf. Accessed: 9 Febraury 2012.

Hoffmann S, Fischbeck P, Krupnick A, McWilliams M. (2006) Eliciting information on uncertainty from heterogeneous expert panels. RFF Discussion Paper RFF DP 06-17-REV. Washington, DC: Resources for the Future.

Hoffmann S, Fischbeck P, Krupnick A, McWilliams M. (2007) Using expert elicitation to link foodborne illnesses in the United States to foods. Journal of Food Protection; 70(5): 1220-1229.

Hoffmann S, Fischbeck P, Krupnick A, McWilliams M. (2008) Informing risk-mitigation priorities using uncertainty measures derived from heterogeneous expert panels: A demonstration using foodborne pathogens. Reliability Engineering and System Safety; 93(5): 687-698.

Knol AB, Slottje P, Van Der Sluijs JP, Lebret E. (2010) The use of expert elicitation in environmental health impact assessment: A seven step procedure. Environmental Health; 9(1): 19.

Lake R, Cressey P, Campbell D, Oakley E. (2010) Risk ranking for foodborne microbial hazards in New Zealand: burden of disease estimates. Risk Analysis; 30(5): 743-752.

Lake R, Horn B, Ball A. (2011) *Campylobacter* in food and the environment examining the link with public health: Pathway attribution. Client Report FW10007. A report for the Ministry of Agriculture and Forestry and the Ministry for the Environment. Available at: http://www.foodsafety.govt.nz/elibrary/industry/examining-link-with-public-health/campylobacter-in-food-and-the-environment-pathway-attribution.pdf. ESR Client Report FW10007. Christchurch: ESR.

Lim E, Tisch C, Cressey P, Pirie R. (2010) Annual report concerning foodborne disease in New Zealand 2009. ESR Client Report FW10040. Christchurch: ESR.

Lim E, Lopez L, Cressey P, Pirie R. (2011) Annual report concerning foodborne disease in New Zealand 2010. ESR Client Report FW10040. Christchurch: ESR.

Lim E, Lopez L, Borman A, Cressey P, Pirie R. (2012) Annual report concerning foodborne disease in New Zealand 2011. ESR Client Report FW12023. Christchurch: ESR.

Ravel A, Davidson VJ, Ruzante JM, Fazil A. (2010) Foodborne proportion of gastrointestinal illness: Estimates from a Canadian expert elicitation survey. Foodborne Pathogens and Disease; 7(12): 1463-1472.

Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, Jones JL, Griffin PM. (2011) Foodborne illness acquired in the United States-major pathogens. Emerging Infectious Diseases; 17(1): 7-15.

Sears A, Baker MG, Wilson N, Marshall J, Muellner P, Campbell DM, Lake RJ, French NP. (2011) Marked campylobacteriosis decline after interventions aimed at poultry, New Zealand. Emerging Infectious Diseases; 17(6): 1007-1015.

Shirazi CH. (2009) Data-informed calibration and aggregation of expert opinion in a Bayesian framework. College Park: University of Maryland.

Slottje P, van Der Sluijs JP, Knol AB. (2008) Expert elicitation. Methodological suggestions for its use in environmental health impact assessments. RIVM Report Number 630004001/2008. Bilthoven: RIVM.

Speirs-Bridge A, Fidler F, McBride M, Flander L, Cumming G, Burgman M. (2010) Reducing overconfidence in the interval judgments of experts. Risk Analysis; 30(3): 512-523.

United States Environmental Protection Agency. (2011) Expert elicitation task force white paper. Washington, DC: USEPA.

Van der Fels-Klerx HJ, Cooke RM, Nauta MN, Goossens LH, Havelaar AH. (2005) A structured expert judgment study for a model of *Campylobacter* transmission during broiler-chicken processing. Risk Analysis; 25(1): 109-124.

Van der Fels-Klerx IHJ, Goossens LHJ, Saatkamp HW, Horst SHS. (2002) Elicitation of quantitative data from a heterogeneous expert panel: Formal process and application in animal health. Risk Analysis; 22(1): 67-81.

Williman J, Cressey P, Pirie R. (2008) Annual report concerning foodborne disease in New Zealand 2007. ESR Client Report FW08056. Christchurch: ESR.

Williman J, Lim E, Pirie R, Cressey P, Lake R. (2009) Annual report concerning foodborne disease in New Zealand 2008. ESR Client Report FW09062. Christchurch: ESR.

APPENDIX 1 DOCUMENTATION PROVIDED TO EXPERT ELICITATION PARTICIPANTS

Expert Elicitation: Foodborne Transmission of Enteric Pathogens in New Zealand

Scope and Protocol
April 2013

Scope definition: What is needed and why?

Required outputs:

Estimates, with associated uncertainties, of the proportion of disease incidence caused by each microbial pathogen that is due to foodborne transmission.

Reason this is needed:

To provide estimates of burden of disease attributed to possible transmission routes, to support risk ranking and policy by MPI.

Reason for using expert elicitation:

These estimates could be generated by other means e.g. attribution modelling based on typing studies, but insufficient data are available.

Expert Selection Process

Research has shown little or no improvement in the aggregate opinions of panels greater than 10 experts, compared to those of about 10. Given New Zealand's size and the relatively modest base of experts in most fields, an expert panel of this size was considered appropriate.

A list of experts was assembled, in consultation with MPI, based on the following criteria:

- New Zealand based
- Evidence of expertise (e.g. publications, field of employment)
- Reputation in the required area of expertise
- Impartiality (no conflict of interest)

Each expert on this list was asked to suggest three other experts who they believed met the selection criteria (a 'snowball' technique). This process quickly achieved an internally consistent set of potential participants. The final panel was selected on the basis of availability and providing a range of organisational affiliations.

Scope definition: Pathogens and transmission routes to be addressed

<u>The pathogens to be addressed are:</u>

Bacteria: *Campylobacter*, *Escherichia coli* O157, *Listeria monocytogenes*, non-Typhi *Salmonella*, non-O157 STEC serotypes, *Vibrio parahaemolyticus*, *Yersinia enterocolitica*

Parasites: *Toxoplasma gondii*

Viruses: Norovirus

Note: The sources of *Campylobacter* have been explored extensively in recent years using genetic typing. However, transmission pathways have been only partially addressed. Addressing *Campylobacter* as part of the expert elicitation will supplement existing transmission route estimates.

<u>The transmission routes to be considered are:</u>

- Animal contact
- Environment (air, soil, recreational contact with water)
- Food
- Human to human
- Water (drinking water only, excluding bottled water)

Definitions of these transmission routes are included in Appendix 1.

The experts will be asked to estimate the proportion of disease attributable to each transmission route, for each pathogen, in order to attribute the total disease incidence. By explicitly considering several transmission routes, it is hoped to avoid overestimation for the foodborne route, and to prevent confusion about the definition of waterborne transmission. This will assist in generating internal consistency in attribution estimates, as experts will need to consider questions such as "If not food, what is the transmission route?" and "If a proportion of the transmission is due to other routes, how much is reasonably due to food?".

In order to not overburden participants, uncertainty information will only be elicited for the food transmission route. Estimates of the contribution of other transmission routes to the total incidence of disease may be provided quantitatively, as point estimates, or qualitatively by placing the possible transmission routes in order of importance. See Appendix 2 for an example from the questionnaire.

The denominator will be all cases of the disease where infection was acquired in New Zealand (excludes travel-related cases).

Specific food/pathogen combinations:

In addition to estimating the overall proportion of disease due to foodborne transmission of the selected enteric pathogens, MPI wish to examine the proportion of disease attributable to principal food vehicles. Pathogen/food vehicle combinations of interest are as follows:

- *Campylobacter*: poultry, red meat
- *Listeria monocytogenes*: ready-to-eat meats
- Norovirus: seafood
- Non-Typhi *Salmonella*: poultry, red meat
- STEC O157: red meat
- STEC non-O157: red meat
- *Vibrio parahaemolyticus*: seafood
- *Yersinia enterocolitica*: pork

Definitions of these foods are included in Appendix 1, and an example from the questionnaire is included in Appendix 2.

The denominator will be all cases of the disease where infection occurred in New Zealand AND food was the transmission route.

Study Protocol

Material to be provided to participants:

Background and training material:

This document provides participants with a clear description of the problem, the parameters to be estimated, and the definitions needed to ensure consistency (e.g. food handlers and norovirus – is this foodborne?). Examples are provided to guide completion of the questionnaire, and additional material has been provided to explain how the results will be aggregated.

The elicitation exercise seeks to draw on individual expert knowledge. Consequently, participants will not be provided with information concerning the organisms and diseases of interest, other than some brief information in the questionnaire. However, such information on the majority of these microbial diseases in New Zealand can be found in the *Annual Report Concerning Foodborne Disease in New Zealand*: http://www.foodsafety.govt.nz/science-risk/human-health-surveillance/foodborne-disease-annual-reports.htm

Questionnaire:

A questionnaire will be provided asking participants to provide estimates for each of the required parameters, to self-assess their expertise, and to describe how they determined their estimates (see Appendix 2 for an example).

Elicitation method and participant interaction:

The elicitation will be conducted as a two-round Delphi allowing feedback of first round aggregated results and revision of estimates, but with no attempt made to generate a consensus value for estimates. Each round will consist of completion of the questionnaire. The final output will be a mathematical combination of estimates from experts who consider themselves well enough informed, with respect to the particular pathogen/disease. This combination will be examined in a number of ways, including equal weighting, self-assessed expertise weighting, and weighting using results from a set of calibration questions (second round only, see weighting of experts, below).

The first round will be conducted by e-mail, with the second round conducted as a facilitated face-to-face meeting. During the e-mail phase, participants can direct questions concerning the completion of the questionnaire to the study co-ordinators. The questions and associated answers will be distributed to all participants.

During the face-to-face meeting, participants will have the opportunity to discuss the outputs from the first round. Participants will be particularly encouraged to discuss any extreme results from the first round. In this context, 'extreme' refers to results that differ markedly from the other panel results.

Participants will then have an opportunity to update their opinions by repeating the elicitation questionnaire.

Weighting of experts:

There is potential in expert elicitation for some participants to be 'better' than others. This may be as a result of their personal knowledge or of their ability to express that knowledge and its associated uncertainty. Several approaches will be used to determine 'weightings' for expertise. These weightings will be used in the results aggregation process.

Participants will be given the opportunity to opt out of providing estimates for specific pathogens/diseases where they consider themselves not qualified.

Equal weighting

Aggregation will be carried out assuming that all participants who express an opinion related to a particular pathogen/disease are equally expert.

Self-assessed weightings

Additionally, participants will be given an opportunity to provide a self-assessment of their expertise with respect to each particular pathogen/disease. Expertise will be expressed on a five-point Likert scale using the following scale descriptors:

1 = low expertise – no direct experience, anecdotal knowledge only
3 = medium expertise – some direct experience, wide reading
5 = high expertise – primary focus of professional work

An example is provided in Appendix 2. These expertise scales will be used to weight individual responses to the overall aggregate estimate.

Calibration weightings

An additional process to derive weights will to be carried out at the face-to-face meeting. This procedure asks experts to provide estimates, with uncertainty, for a set of parameters which are related to the field of expertise of the participants and for which the values are known to the study co-ordinators, but are different from those for which the elicitation is being conducted. Performance in estimating these "seed" variables is based on the precision of the estimate and also the uncertainty. Scoring rules are used to assign weights to individual participants for use in the aggregation process. This approach is relatively new for food safety, and so we are using it as only one of the aggregation options.

<u>Framing of questions:</u>

Each question will be framed using natural frequencies ("Out of 100 cases how many…."). A four point method will be used, which generates estimates for a minimum value, maximum value and most likely value, plus a fourth value that indicates the participant's confidence in these three estimates (see Appendix 3 for more details). Participants will be asked to provide reasons for their estimates (see Appendix 2 for an example).

Post-elicitation

<u>Aggregation method:</u>

The four-point estimates from each participant will be used to define a Beta Pert distribution representing the participant's opinion (see Appendix 3 for more details). An aggregate estimate of each parameter and its associated uncertainty will be determined by simulation (Monte Carlo sampling of all participants' distributions from four point method, weighted by the methods outlined above.

<u>Final results:</u>

The aggregated output from the final (face-to-face) meeting will be documented and distributed to all expert panel members. Dissemination will only occur after participants are satisfied that the output is a fair representation of the elicitation process.

Feedback will be provided to all participants of how their individual estimates compared to the aggregated estimate.

Appendix 1: Definitions

Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). **This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.**
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Foods

Ready-to-eat (RTE) meats

- Uncooked cured shelf stable meats, dry cured hams, Chinese sausage, fermented high acid sausage, salami, pepperstick, biersticks, mettwurst, rockwurst, biltong, Rou Gan, beef jerky
- Cooked meats not reheated before consumption
- Cooked perishable cured meats pressed ham, emulsion style sausages, pastrami, whole hams, silverside, corned beef, continental sausages, luncheon meats, saveloys, cocktail sausages etc., frankfurters, pâté, liverwurst.

Poultry

- Chicken
- Turkey
- Duck

Red meat

- beef and veal
- small game animals (including rabbits)
- horse meat
- deer and elk (wapiti) meat
- mutton, lamb and goat meat
- pork

Seafood

- fish (or finfish)
- molluscan shellfish
- crustacea

Mollusca:

- Cockle
- Pipi
- Toheroa
- Tuatua
- Mussel, blue
- Mussel, green
- Oyster, dredge
- Oyster, Pacific
- Oyster, rock
- Scallop

Crustacea:

- Shrimp/prawn
- Crayfish/lobster
- Crab

Appendix 2: Elicitation worked example

Please note this example is not related to any particular pathogen.

Self-assessment of expertise with respect to the organisms of interest

For each organism listed below, what level of expertise would you describe yourself as having with respect to the organism, disease due to the organism and foodborne transmission of the organism?

For each pathogen listed below, please indicate your opinion of your level of expertise by circling one number in the five-point scale to the right of the organism's name. The scale ranges from 1 = least expert to 5 = most expert. Descriptors for expertise levels 1, 3 and 5 are:

1 = low expertise – no direct experience, anecdotal knowledge only
3 = medium expertise – some direct experience, wide reading
5 = high expertise – primary focus of professional work

Expertise levels 2 and 4 should be treated as describing expertise intermediate between these levels.

Indicate your level of expertise by circling the number that you feel most accurately reflects your level of expertise.

If you feel that you lack sufficient expertise to provide opinions related to the particular organism, do not mark any number and instead clearly tick the box labelled 'No response'.

	No response					
Organism 1	☐	**1**	**2**	**3**	**4**	**5**
Organism 2	☑	**1**	**2**	**3**	**4**	**5**

In this example, the participant has indicated that they believe their level of expertise on Organism 1, the disease caused by Organism 1 and foodborne transmission of Organism 1 to be between medium and high. The participant also feels that they lack sufficient expertise on Organism 2.

Estimate of proportion attributable to foodborne transmission

For 100 cases of disease due to infection by Organism 1 occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (minimum)?	2
• What is the highest number of cases that may be due to foodborne transmission (maximum)?	25
• What is the most likely number of cases that would be due to foodborne transmission (most likely)?	15
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	80

What knowledge or experience have you primarily based these estimates on?

I am a health protection officer and have investigated many cases of infection by Organism 1 during 2012. I have based my estimates on my experience.

In this example, the participant has indicated that they are 80% certain that the number of cases (out of every 100 cases) lies between 2 and 25, and the most likely number of cases is 15. They have provided some information to support their estimates.

Estimates of the proportions attributable to other transmission routes

Consider the '**most likely**' value you have given for foodborne transmission of Organism 1.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

See Appendix 1 in the training material for a reminder on the definitions for each transmission route.

Disease due to organism

Transmission route	**Number of cases (0-100)**	**Ranking (1-5)**
Environment	20	
Animal contact	5	
Food	15	
Human-to-human	45	
Water	15	
	Total = 100	

OR

Transmission route	**Number of cases (0-100)**	**Ranking (1-5)**
Environment		2
Animal contact		5
Food		3=
Human-to-human		1
Water		3=
	Total = 100	

Two examples are shown above – one where the participant has estimated cases based on numbers out of 100, and another where the participant has used ranking. In both examples, the participant has based their estimates for other transmission routes by first considering their 'most likely' estimate for food.

Estimate of proportions due to specific foods

Food 1

For 100 **foodborne** cases of disease due to infection by Organism 1 occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **Food 1** (minimum)?	60
• What is the highest number of cases that may be due to transmission by **Food 1** (maximum)?	90
• What is the most likely number of cases that would be due to transmission by **Food 1** (most likely)?	70
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	90

What was the primary basis for your estimate?

I am a health protection officer and have investigated many cases of infection by Organism 1 during 2012. I have based my estimates on my experience. Most of the cases I have investigated have named Food 1 as a food they had consumed within the infective period for Organism 1.

In this example, the participant has indicated that they are 90% certain that the number of foodborne cases attributed to Food 1 (out of every 100 foodborne cases) lies between 60 and 90, and the most likely number of cases is 70. They have provided some information to support their estimates.

Appendix 3: Training Material

Subjective Probability Distributions (SPD)

To get probability distributions for a characteristic for which few data are available, analysts have often proposed tapping the resources of expert judgment and eliciting subjective probability distributions (SPD) to quantify uncertainty. The most common form on this process is to elicit either estimates of location and scale parameters or to obtain expert estimates of specific quantiles of the uncertainty distribution. These estimates will usually be combined with an assumption of a particular distribution type to define a SPD.

In this context, a SPD is a means of codifying expert knowledge, including the uncertainty associated with that knowledge.

The simplest form of a SPD and one often used to represent expert opinion is the triangular distribution. This distribution has three parameters:

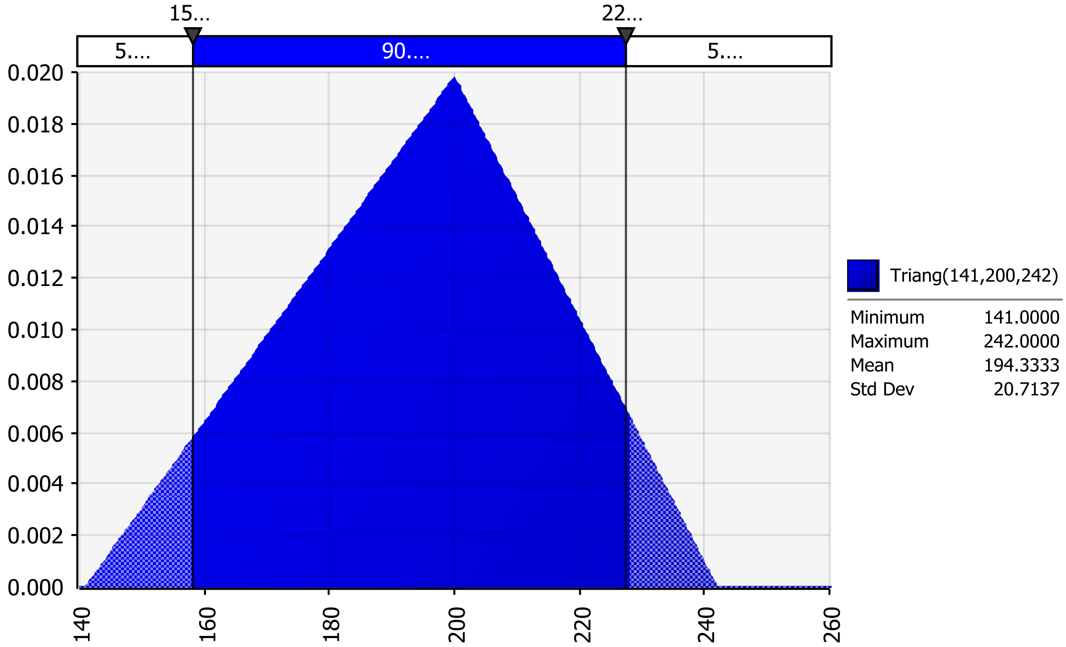
- Minimum ("What is the lowest value the parameter could take")
- Maximum ("What is the greatest value the parameter could take")
- Mode ("What is the most likely value of the parameter")

For example, if we are asked to estimate the distance from Palmerston North to Napier, we may know that it is greater than the distance from Palmerston North to Wellington and may know that that distance is 141 km. We may also be fairly certain that the distance is less than the distance from Palmerston North to Taupo and know that that distance is 242 km. Our expert opinion may be that the distance from Palmerston North to Napier is 200 km.

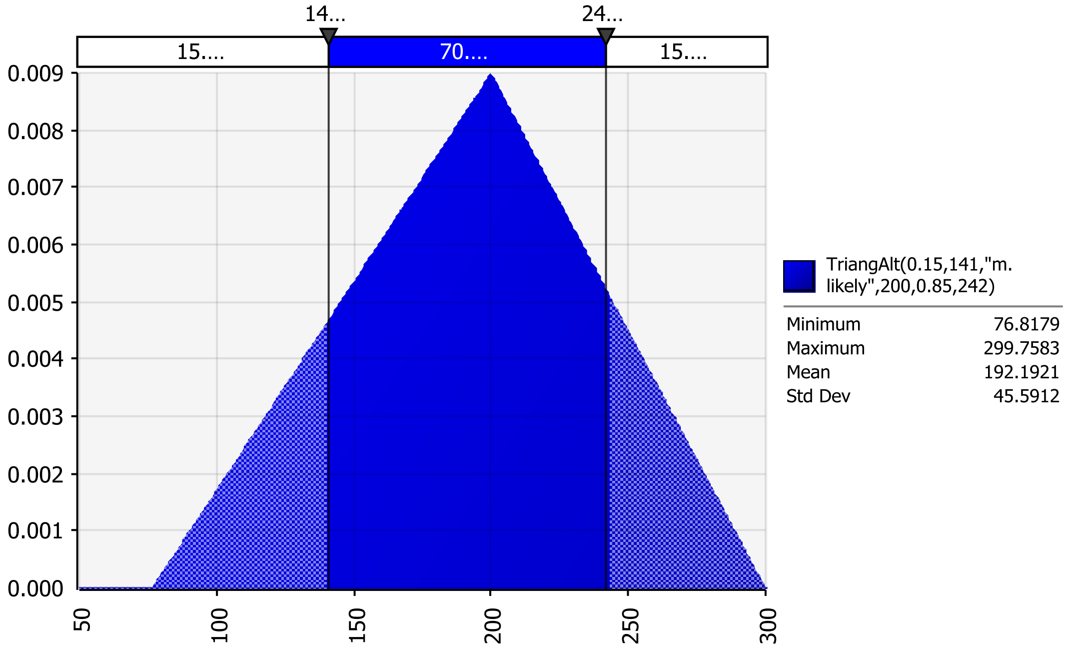
The technique to be used for the 2013 Foodborne illness attribution study will ask a fourth question, "How confident are you (0-100%) that the interval you have created (minimum to maximum) will contain the true value?". An alternative way of think of this is, "If you defined 100 intervals for similar problems, how many of them would you expect to contain the true value".

This allows the width (scale) of the SPD to be inflated to represent this uncertainty. So, if the respondent to the question above felt they were 70% confident that the true distance from Palmerston North to Napier was in the range 141-242 km, then the resultant SPD would be adjusted so that the range 141-242 km represented 70% of the total probability distribution.

This information from the three point estimate can be represented by the triangular distribution Triang(141,200,242).

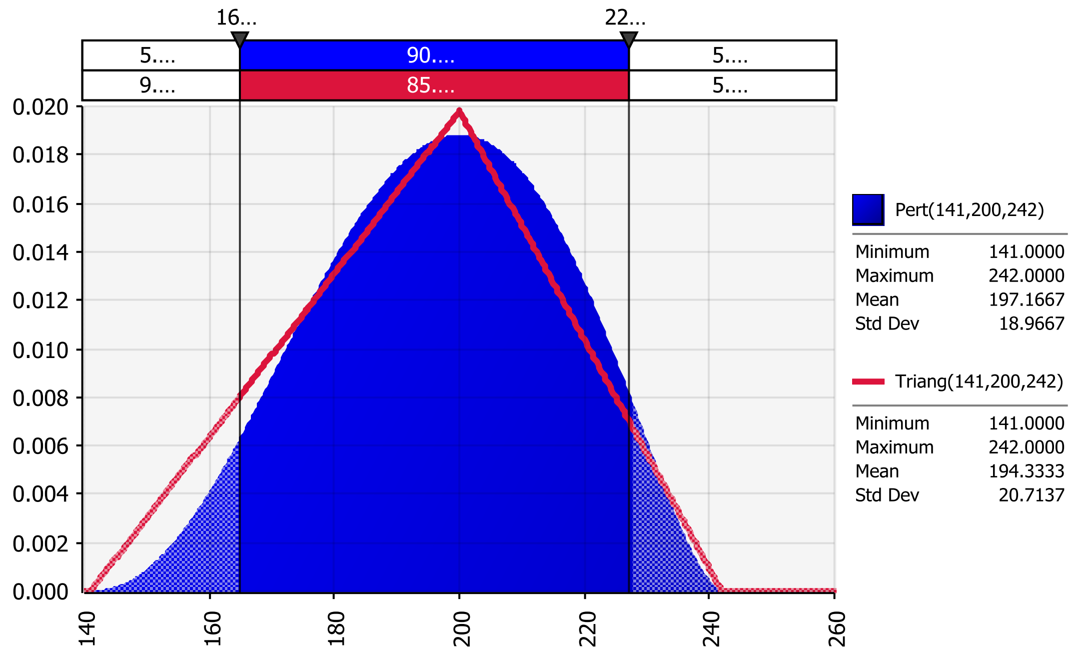


The information from the four point estimate can be represented by an inflated triangular distribution.



The inclusion of the expert's expression of confidence now means that the SPD encompasses all distances from 77 to 300 km. A domain expert addressing issues within their field of expertise would normally be expected to have greater than 70% confidence in the interval they have specified. However, the definition of the interval range and the expression of a level of confidence are quite distinct cognitive processes and experts are encouraged to express what they believe, rather than what they feel they should believe!

The triangular distribution is a ‘tail heavy’ distribution and the same expert information (minimum, most likely, maximum) can also be used to define a Pert distribution. This distribution is a special form of the Beta distribution. See below the Pert distribution for the three point estimate for the Palmerston North-Napier exercise, with the corresponding triangular distribution overlayed.



Compared to the triangular distribution, the pert distribution concentrates more of the probability density around the ‘most likely’ value and less around the ‘minimum’ and ‘maximum’ values.

Sources of Bias

Two major sources of potential bias in expert opinion have been identified:

- Systematic under- or over-estimation; and
- Overconfidence (a tendency to estimate overly narrow confidence intervals around variable estimates).

Systematic bias may occur as a tendency to over-estimate the occurrence of very rare events or to under-estimate the occurrence of very common events. In a study similar to the current one, it has been noted that experts are generally unwilling to ascribe all (100%) or none (0%) of the disease due to a particular organism to the foodborne route.

Overconfidence can be decreased by actively trying to identify evidence that contradicts your opinion.

The structuring of questions has also been suggested as a means of reducing overconfidence, with respondents first asked for a range that they believe the actual value will fall within and then asking how confident the expert is that the true value will fall within that range.

An advocacy or adversarial approach has also been suggested as a means of reducing overconfidence, particularly in the estimation of rare events. Under this approach, the expert is 'challenged' by a panel of impartial judges. The process of advocating for their opinion is believed to reduce overconfidence. The face-to-face meeting offers this opportunity.

<u>Heuristics and biases</u>

Heuristics are 'rules of thumb' that individuals use to make decisions and form judgments. Some common heuristics have the potential to introduce biases into expert elicitations. Several common relevant biases resulting from heuristics are:

- Availability. The ease of recall of a recent experience may mean that the recent dominates over the distant, even though they may be of equal probability.
- Representativeness. Inappropriate generalisation of specific knowledge or paying too much attention to specific details at the cost of background information. This is also known as 'base rate neglect'.
- Anchoring. The adoption of a first estimate and the process of relating or anchoring subsequent estimates to that first estimate.
- Adjustment. Related to anchoring. A tendency to arrive at new estimates by adjusting from old estimates.

These biases can be counteracted to some extent by asking experts to formulate arguments or justifications in support of their judgments.

The manner in which questions are framed and including a request for participants to provide evidence for their estimates ("what is the primary basis for your estimate?") helps to counteract some of these biases. Participant awareness of potential sources of bias is also important.

Expert Elicitation: Foodborne Transmission of Enteric Pathogens in New Zealand

QUESTIONNAIRE

May 2013

Questionnaire Identifier	
Name of expert	
Organisational affiliation	

Instructions

- Read all instructions and explanatory material
- Provide responses only in shaded spaces
- If you have any questions, contact:

Rob Lake

rob.lake@esr.cri.nz

(03) 351 0048

OR

Peter Cressey

peter.cressey@esr.cri.nz

(03) 351 0037

Self-assessment of expertise with respect to the pathogens of interest

For each pathogen listed below, what level of expertise would you describe yourself as having with respect to the pathogen, disease due to the pathogen and foodborne transmission of the pathogen?

For each pathogen listed below, please indicate your opinion of your level of expertise by circling one number in the five-point scale to the right of the organism's name. The scale ranges from 1 = least expert to 5 = most expert. Descriptors for expertise levels 1, 3 and 5 are:

1 = low expertise – no direct experience, anecdotal knowledge only
3 = medium expertise – some direct experience, wide reading
5 = high expertise – primary focus of professional work

Expertise levels 2 and 4 should be treated as describing expertise intermediate between these levels.

Indicate your level of expertise by circling or otherwise clearly marking the number that you feel most accurately reflects your level of expertise.

If you feel that you lack sufficient expertise to provide opinions related to the particular organism, do not mark any number and instead clearly tick the box labelled 'No response'.

If you tick the box labelled 'No response', DO NOT complete the questionnaire sections relating to that pathogen.

	No response					
Campylobacter	☐	**1**	**2**	**3**	**4**	**5**
Listeria monocytogenes	☐	**1**	**2**	**3**	**4**	**5**
Norovirus	☐	**1**	**2**	**3**	**4**	**5**
Non-Typhi *Salmonella*	☐	**1**	**2**	**3**	**4**	**5**
STEC O157	☐	**1**	**2**	**3**	**4**	**5**

STEC non-O157	☐	**1**	**2**	**3**	**4**	**5**
Toxoplasma gondii	☐	**1**	**2**	**3**	**4**	**5**
Vibrio parahaemolyticus	☐	**1**	**2**	**3**	**4**	**5**
Yersinia enterocolitica	☐	**1**	**2**	**3**	**4**	**5**

Campylobacter

There are many species of *Campylobacter* but the evidence in New Zealand suggests that two species, *C. jejuni* and *C. coli*, are of major significance to public health. Other species, such as *C. upsaliensis*, *C. fetus*, *C. hyointestinalis* and *C. lari* have occasionally been reported as causing human illness but their significance in New Zealand is unknown as different isolation methods are required for these organisms.

Estimate of proportion attributable to foodborne transmission- *Campylobacter*

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by *Campylobacter* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes - *Campylobacter*

Consider the '**most likely**' value you have given for foodborne transmission of *Campylobacter*.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	**Number of cases (0-100)**	**Ranking (1-5)**
Environment		
Animal contact		
Food		
Human-to-human		
Water		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods - *Campylobacter*

Poultry

For this exercise, **poultry** includes chickens (*Gallus gallus*), turkeys and ducks, but excludes other types of poultry such as goose, pigeon and ostrich**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from chicken being prepared at the same time, then the infection should be considered as due to chicken.

For **100 foodborne** cases of disease due to infection by *Campylobacter* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **poultry** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **poultry** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **poultry** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Red meat

For this exercise, **red meat** includes beef and veal, small game animals (including rabbits), horse meat, deer and elk (wapiti) meat, mutton, lamb and goat meat, and pork**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from red meat being prepared at the same time, then the infection should be considered as due to red meat.

For **100 foodborne** cases of disease due to infection by *Campylobacter* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **red meat** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **red meat** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **red meat** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Escherichia coli O157 infection

There are two acronyms that are in common use that pertain to this group of organisms. The two most commonly used currently are VTEC (verocytotoxigenic *Escherichia coli*) and STEC (shiga toxigenic *Escherichia coli*). The two acronyms have now become *de facto* synonyms, but "shigatoxigenic *E. coli*" (also STEC) has been proposed to cover this group. **The serotype of STEC that has been most studied is *E. coli* O157:H7, but participants should consider all O157 STEC. Non-O157 STEC are covered in a separate section in this questionnaire**.

Estimate of proportion attributable to foodborne transmission – *E. coli* O157

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by *Escherichia coli* O157 occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes – *E. coli* O157

Consider the '**most likely**' value you have given for foodborne transmission of *E. coli* O157.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	**Number of cases (0-100)**	**Ranking (1-5)**
Human-to-human		
Environment		
Food		
Animal contact		
Water		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods – *E. coli* O157

Red meat

For this exercise, **red meat** includes beef and veal, small game animals (including rabbits), horse meat, deer and elk (wapiti) meat, mutton, lamb and goat meat, and pork**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from red meat being prepared at the same time, then the infection should be considered as due to red meat.

For **100 foodborne** cases of disease due to infection with *E. coli* O157 occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **red meat** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **red meat** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **red meat** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Listeria monocytogenes

Six species comprise the genus *Listeria*. *L. grayi* and *L. innocua* are considered non-pathogenic, while *L. seeligeri*, *L. ivanovii*, and *L. welshimeri* are rarely causes of human infection. *L. monocytogenes* is the most important species with respect to human health.

Two forms of disease caused by this organism are now recognised; a serious invasive disease and a non-invasive gastroenteritis. While the invasive form of disease is uncommon, the clinical consequences are often serious. The current exercise is only concerned with the invasive form of the disease.

Estimate of proportion attributable to foodborne transmission – *L. monocytogenes*

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by *Listeria monocytogenes* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes – *L. monocytogenes*

Consider the '**most likely**' value you have given for foodborne transmission of *Listeria monocytogenes*.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	**Number of cases (0-100)**	**Ranking (1-5)**
Water		
Human-to-human		
Animal contact		
Environment		
Food		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods – *L. monocytogenes*

Ready-to-eat (RTE) meats

For this exercise, **RTE meats** includes products whose processing includes one or more pathogen control steps to render the products safe for consumption without further processing or cooking by the consumer. The processed meats considered in this category principally include the red meats pork, beef, and lamb, or mixed species products. Poultry products are also included, as ready-to-eat poultry products will usually be processed, sold and consumed in the same way as red meat products.

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from RTE meat being prepared at the same time, then the infection should be considered as due to RTE meat.

For **100 foodborne** cases of disease due to infection with *Listeria monocytogenes* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **RTE meat** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **RTE meat** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **RTE meat** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Non-Typhi *Salmonella*

This group of bacteria is comprised of two species: *Salmonella enterica,* which is divided into 6 subspecies (*enterica, salamae, arizonae, diarizonae, houtanae* and *indica*), and *Salmonella bongori*. Most pathogenic isolates from humans and other mammals belong to subspecies I: *Salmonella enterica* subspecies *enterica*. *Salmonella enterica* serotypes are normally denoted in a shortened form that includes a non-italicised serotype name, e.g. *Salmonella enterica* subsp. *enterica* serotype Enteritidis becomes *Salmonella* Enteritidis. In New Zealand, most cases of salmonellosis are caused by *Salmonella* Typhimurium.

Salmonella Typhi and *Salmonella* Paratyphi are serotypes which cause a serious enteric fever and are particularly well adapted to invasion and survival in human tissue. They have a particular antigen makeup and differing ecology to other serotypes of *Salmonella*. *Salmonella* Choleraesuis (SCS) is the equivalent porcine typhi-like serotype. SCS is not found in many countries but has a distinct pathogenic profile.

Participants should only consider serotypes of *Salmonella enterica* subspecies *enterica*, excluding Typhi, Paratyphi and SCS.

Estimate of proportion attributable to foodborne transmission - *Salmonella*

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by non-Typhi *Salmonella* (excluding cases where infection occurred overseas) occurring in 2012:

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes - *Salmonella*

Consider the '**most likely**' value you have given for foodborne transmission of non-Typhi *Salmonella*.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	Number of cases (0-100)	Ranking (1-5)
Food		
Animal contact		
Water		
Environment		
Human-to-human		
	Total = 100	

<u>Definitions - Transmission routes</u>

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods - *Salmonella*

Poultry

For this exercise, **poultry** includes chickens (*Gallus gallus*), turkeys and ducks, but excludes other types of poultry such as goose, pigeon and ostrich**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from chicken being prepared at the same time, then the infection should be considered as due to chicken.

For **100 foodborne** cases of disease due to infection with non-Typhi *Salmonella* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **poultry** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **poultry** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **poultry** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Red meat

For this exercise, **red meat** includes beef and veal, small game animals (including rabbits), horse meat, deer and elk (wapiti) meat, mutton, lamb and goat meat, and pork**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from red meat being prepared at the same time, then the infection should be considered as due to red meat.

For **100 foodborne** cases of disease due to infection with non-Typhi *Salmonella* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **red meat** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **red meat** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **red meat** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Non-O157 STEC Serotypes

There are two acronyms that are in common use that pertain to this group of organisms. The two most commonly used currently are VTEC (verocytotoxigenic *Escherichia coli*) and STEC (shiga toxigenic *Escherichia coli*). The two acronyms have now become *de facto* synonyms, but "shigatoxigenic *E. coli*" (also STEC) has been proposed to cover this group. The serotype of STEC that has been most studied is *E. coli* O157:H7. **The following questions relate to all STEC strains, except O157**.

Estimate of proportion attributable to foodborne transmission – non-O157 STEC

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by non-O157 STEC serotypes occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes – non-O157 STEC

Consider the '**most likely**' value you have given for foodborne transmission of non-O157 STEC serotypes.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	Number of cases (0-100)	Ranking (1-5)
Environment		
Food		
Animal contact		
Water		
Human-to-human		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods – non-O157 STEC

Red meat

For this exercise, **red meat** includes beef and veal, small game animals (including rabbits), horse meat, deer and elk (wapiti) meat, mutton, lamb and goat meat, and pork**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from red meat being prepared at the same time, then the infection should be considered as due to red meat.

For **100 foodborne** cases of disease due to infection with non-O157 STEC serotypes occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **red meat** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **red meat** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **red meat** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Vibrio parahaemolyticus

The genus *Vibrio* includes several pathogens which cause a spectrum of clinical conditions including septicaemia, cholera and milder forms of gastroenteritis. The species most commonly associated with foodborne transmission include *V. cholerae*, *V. parahaemolyticus*, and *V. vulnificus*. *V. cholerae*, which may cause cholera, and *V. vulnificus* are not included in this elicitation. *V. parahaemolyticus* may also cause wound infections through skin exposure to contaminated sea water. **The following questions relate only to enteric disease due to *V. parahaemolyticus.***

Estimate of proportion attributable to foodborne transmission – *V. parahaemolyticus*

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by *Vibrio parahaemolyticus* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes – *V. parahaemolyticus*

Consider the '**most likely**' value you have given for foodborne transmission of *Vibrio parahaemolyticus*.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	**Number of cases (0-100)**	**Ranking (1-5)**
Water		
Animal contact		
Environment		
Food		
Human-to-human		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods – *V. parahaemolyticus*

Seafood

For this exercise, **seafood** includes fish (or finfish), molluscan shellfish, and crustacea**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from seafood being prepared at the same time, then the infection should be considered as due to seafood.

For **100 foodborne** cases of disease due to infection with *Vibrio parahaemolyticus* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **seafood** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **seafood** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **seafood** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Yersinia enterocolitica

Yersinia enterocolitica is one of the three species of *Yersinia* considered to be pathogenic to humans and animals. The others are *Yersinia pseudotuberculosis* which causes inflammation of the lymph nodes, and *Yersinia pestis*, which was responsible for the bubonic plague. The latter two species are not associated with foodborne transmission. Participants should only consider infections caused by *Y. enterocolitica*.

Estimate of proportion attributable to foodborne transmission – *Y. enterocolitica*

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by *Yersinia enterocolitica* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes – *Y. enterocolitica*

Consider the '**most likely**' value you have given for foodborne transmission of *Yersinia enterocolitica*.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	Number of cases (0-100)	Ranking (1-5)
Animal contact		
Environment		
Human-to-human		
Food		
Water		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods – *Y. enterocolitica*

Pork

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from pork being prepared at the same time, then the infection should be considered as due to pork.

For **100 foodborne** cases of disease due to infection with *Yersinia enterocolitica* occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **pork** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **pork** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **pork** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Toxoplasma gondii

Toxoplasma gondii is classed as a Category 4 parasite, in that cysts or eggs are shed with faeces of the reservoir definitive host (in this case members of the cat family), in which the organism is able to reproduce sexually in large numbers. Excreted organisms are able to infect intermediate hosts such as warm blooded animals (including humans) and birds. The intermediate hosts are often also major food sources for humans e.g. livestock providing red meat.

Estimate of proportion attributable to foodborne transmission – *T. gondii*

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by *Toxoplasma gondii* (excluding cases where infection occurred overseas) occurring in 2012:

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes – *T. gondii*

Consider the '**most likely**' value you have given for foodborne transmission of *Toxoplasma gondii*.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	Number of cases (0-100)	Ranking (1-5)
Environment		
Animal contact		
Water		
Human-to-human		
Food		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Norovirus

Human noroviruses are now the most common cause of reported outbreaks of epidemic non-bacterial gastroenteritis world-wide. These viruses were previously known as Norwalk-like viruses (NLVs) or small round structured viruses (SRSVs). The only known reservoir for human norovirus is human faeces. Human noroviruses contaminate filter feeding bivalve molluscan shellfish through faecal contamination of growing waters. Fresh produce may be contaminated through contaminated irrigation or processing water. Manually prepared ready-to-eat foods may be contaminated by infected food handlers. In addition to contaminated food or water, person-to-person transmission is important, either directly or via contaminated surfaces and objects. In outbreaks, multiple transmission routes may occur simultaneously.

Estimate of proportion attributable to foodborne transmission - norovirus

'Foodborne transmission' is defined as transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.

For **100** cases of disease due to infection by norovirus occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to foodborne transmission (**minimum**)?	
• What is the highest number of cases that may be due to foodborne transmission (**maximum**)?	
• What is the most likely number of cases that would be due to foodborne transmission (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Estimates of the proportions attributable to other transmission routes - norovirus

Consider the '**most likely**' value you have given for foodborne transmission of norovirus.

Using the table below EITHER enter the most likely number of cases (out of 100) that would be due to transmission by each of the transmission routes **OR** rank the transmission routes with respect to their contribution to 100 cases (1 = most cases, 5 = least cases).

Ties are allowed. If you believe that two transmission routes contribute equally to the disease burden then assign the same number of cases to both **OR** place the same ranking number and a '=' symbol next to the two transmission routes. For example, if you believe that two routes equally account for the second highest number of cases then entries will be 1, 2=, 2=, 4, 5.

Disease due to organism

Transmission route	Number of cases (0-100)	Ranking (1-5)
Food		
Human-to-human		
Water		
Animal contact		
Environment		
	Total = 100	

Definitions - Transmission routes

Food	Transmission through food that is contaminated at source (e.g. colonisation of food animal) or during processing and preparation (preparation might be in any location, including kitchens, outdoor venues, abattoirs, food processing lines, etc.). This includes food contaminated by food handlers and infections in people who have handled contaminated foods. Bottled water is also included as food.
Water	Transmission through contaminated drinking water from any reticulation system (including municipal and private supplies such as rainwater supplies). This excludes incidental ingestion of recreational water (e.g. while swimming) and consumption of bottled water.
Environmental	Transmission through environmental matrices (air, soil, recreational water), from which pathogens are intentionally or incidentally ingested.
Animal contact	Transmission by direct contact with animals, including farm animals, pets, petting zoos, working at livestock processing plants, etc.
Human-to-human	Transmission from one infected person to another person.

Estimate of proportions due to specific foods - norovirus

Seafood

For this exercise, **seafood** includes fish (or finfish), molluscan shellfish, and crustacea**.**

N.B. For this estimate, disease should be attributed to the food that is responsible for introducing the pathogen into the food preparation/consumption environment. Even though cross-contamination may occur in the kitchen, we wish to obtain an estimate for the original food source of the contamination.

For example, if an infection was the result of someone consuming lettuce that had been contaminated from seafood being prepared at the same time, then the infection should be considered as due to seafood.

For **100 foodborne** cases of disease due to infection with norovirus occurring in 2012 (excluding cases where infection occurred overseas):

• What is the lowest number of cases that must be due to transmission by **seafood** (**minimum**)?	
• What is the highest number of cases that may be due to transmission by **seafood** (**maximum**)?	
• What is the most likely number of cases that would be due to transmission by **seafood** (**most likely**)?	
• How confident are you (0-100%) that the interval you have defined (minimum-maximum) will contain the true value?	

What knowledge or experience have you primarily based these estimates on?

Expert Elicitation: Foodborne Transmission of Enteric Pathogens in New Zealand

CALIBRATION QUESTIONNAIRE

5 June 2013

Questionnaire Identifier	
Name of expert	
Organisational affiliation	

Background

Cooke's classical method for expert elicitation

Cooke's so-called classical approach combines expert opinions using a linear opinion pool. The classical model assumes that the performance of the experts on the variables of interest (query variables) can be judged on the basis of their previous performance on a set of 'seed' or calibration variables. These will be variables within the expert's knowledge domain that are not explicitly known to the expert at the time of calibration, but are or will be known to the person conducting the survey. Performance in estimating these seed variables can then be used to calibrate the expert's performance with respect to the query variables (Cooke and Goossens, 1999).

In our New Zealand expert elicitation we have chosen the Delphi approach and asked participants to provide a self-assessment of their expertise on a pathogen-by-pathogen basis. To give us an alternative for analysing the results we would like to examine how a participant weighting based on the use of seed variables might affect the overall estimates. We have attempted to identify seed variables that are relevant to New Zealand or Australia, and within the broad expertise of the group. We are asking for your best estimate (most likely), as well as low (minimum) and high (maximum) boundaries. Performance by experts is based partly on correct estimation of the parameter (calibration), and confidence derived from the low and high estimate interval (information).

Please tell us if you know the specific answer to any of these questions rather than providing an estimate.

Q1: In New Zealand, norovirus outbreaks are reported to the surveillance system via the EpiSurv outbreak surveillance module. The number of outbreak cases reported represents a fraction of the total community cases. Estimates of the number of community cases in New Zealand for 2011 have been calculated based on population rates of norovirus infection, derived from overseas studies.

What percentage of the estimated community cases of norovirus infection in 2011 were represented by norovirus outbreak cases in 2011?

Minimum		%
Maximum		%
Most likely		%

Q2: Kirk et al (2012) estimated the rate of food or waterborne campylobacteriosis infections between 2000-2009 among elderly Australians **living in long term care facilitie**s.

What was the estimated rate per 100,000 of food or waterborne infections with *Campylobacter* for elderly Australians (>65 years) living in long term care facilities?

Minimum		Per 100,000
Maximum		Per 100,000
Most likely		Per 100,000

Q3: Two large national surveys conducted in 2001 and 2008 were analysed to examine incidence and outcomes of gastroenteritis in older Australians (Kirk et al., 2012). A case was someone reporting ≥3 loose stools or ≥1 episode of vomiting in 24 h, excluding non-infectious causes.

What was the overall rate of episodes of gastroenteritis per person per year in the elderly (≥65 years) across the two surveys?

Minimum		Episodes per person per year
Maximum		Episodes per person per year
Most likely		Episodes per person per year

Q4: The Ministry of Health Annual Review of Drinking-Water Quality in New Zealand 2007/8 reported the percentage of reticulated drinking-water supplies that were not compliant with the distribution zone *E. coli* requirements of the Drinking Water Standards of New Zealand.

What percentage of registered supplies were non-compliant due to unacceptable levels of *E. coli*?

Minimum		%
Maximum		%
Most likely		%

Q5: In a 2005 survey (Gilbert et al., 2007), New Zealand consumers were asked where meat and poultry were thawed in their households.

What percentage of respondents thawed meat or poultry at room temperature?

Minimum		%
Maximum		%
Most likely		%

Q6: A survey of community and hospital laboratories in New Zealand conducted in 2006 requested information on routine tests conducted on faecal samples (Lake et al., 2009).

What percentage of laboratories reported that (at that time) they would conduct routine testing of faecal samples for *E. coli* 0157?

Minimum		%
Maximum		%
Most likely		%

Q7: A survey of chicken meat in Adelaide conducted in 2008 examined the prevalence of *Salmonella* spp. (Fearnley et al., 2011).

What percentage of retail chicken samples in the survey were positive for *Salmonella*?

Minimum		%
Maximum		%
Most likely		%