Probabilistic Inversion in Priority Setting of Food Borne Pathogens

Ángela Patricia Vargas Galindo

Supervisor:

Prof. Roger Cooke

Delft University of Technology
Department of Applied Mathematics and Risk Analysis

Table of Contents

Tables

Figures

Acknowledgment

This document reflects not only the work of the author but also the effort of many people related to this project. I am very thankful to Dr. Arie Havelaar for the trust and time he dedicated to this project. I want to thank my supervisor Prof. Roger Cooke for all his contributions, suggestions and support throughout the project. My thanks are also to Rabin Neslo for the design and construction of the website for the data recollection and for Patrycja Jesionek ‘s help in the first stages of the project. Finally I would like to express my gratitude to all the experts who participated in this exercise.

During the past two years I have learned a lot; about mathematics, life and myself. I want to thank all the people who helped in this learning process. I will always be thankful to Dr. Roger Cooke and Dr. Dorota Kurowicka for always being open to hear my problems and worries, to Sandra and Oswaldo for being a great support and offering their friendship and finally to all my classmates: I couldnot ask for better group, thanks for you help and patience, especially to Wiktoria Ławniczak, Marcin Glegola and Carlos Gonzalez. My special thanks to David García, who was my everyday encouragement and companion in small and big crisis. Finally, to my parents who supported me all the way through.

CHAPTER 1: INTRODUCTION

Food safety is a growing concern in world's health. All population is at risk of getting a food borne illness. Both developed and developing countries have multiple cases of deaths due to food poisoning. According to the World Health Organization during year 2000, 2.1 million people died from diarrhea diseases from which a large proportion can be related with contamination of food borne illnesses

As an example of developed countries, each year in the United States there are approximately 76 million cases of food borne illnesses, from which 325,000 are hospitalized and 5,000 die. In developing countries there is a bigger diversity of food borne diseases and the cases are often not reported. Additionally to single cases there are food borne diseases outbreaks, which often create huge health crisis. In September 2006 one deceased and 113 ill Americans were the victims of an outbreak of E. coli affecting 21 states; apparently the source of the bacteria was fresh spinach from infected by manure from a California cattle ranch near spinach fields.

In the Netherlands, there are between 300,000 and 700,000 cases of gastroenteritis and between 20 and 200 deaths caused by food borne infections, each year. (Knaap, et al. 2006)

Infections diseases may be far from being number one cause of death, but for the elderly, infant population, pregnant women and the HIV/AIDS persons, this type of disease is one of the most dangerous, since their immune system is especially vulnerable. For instance, malnutrition affects 100 million young children and pregnant women, which weakens their immune system making more vulnerable to pathogens and infections.

The transmission of infections diseases is related to various pathogens, agents which cause a disease or illness. Pathogens can be bacteria, viruses or parasites among other. However pathogens like Salmonella and E. coli are not exclusively transmitted by food. Transmission can also be possible by animal contact, having contact with an ill person or even by air.

The National Institute for Public Health and the Environment (RIVM) is an organization dedicated to do research and modeling in health, nutrition and environmental protection. In the Netherlands, RIVM, is responsible for studying food safety issues. According to RIVM, it is important to focus on the most relevant pathogens in order to control, prevent and monitor the behavior of these illnesses effectively. In a previous study, RIVM calculated the disease burden and costs for a set of pathogens. However it is needed to have a more detailed study in order to develop preventive measures and policies meaning that, it is very valuable to have desegregated data regarding the origin of the pathogen and how transmission takes place.

The aim of this project is to determine the fraction of transmission route for each pathogen included in the study and the fraction transmission due to specific food groups, within the cases caused by food ingestion. The objective is to find a fast, not resource intensive and accurate method of estimation for these fractions.

The present document is organized as follows: Chapter two includes a brief explanation of the content of previous RIVM documents and state of the art. Chapter three and four include an explanation of the mathematical tools used in this study. Chapter five describes the methodology used to apply Probabilistic Inversion as well as an explanation the data, the experts and the models used. Conclusions and recommendations are contained in chapter six. Finally, a detailed description of the results is included in the appendix.

CHAPTER 2: PROBLEM DESCRIPTION AND STATE OF THE ART

The criteria often used to determine the relative importance of food borne illnesses include: disease burden, social cost, trends, response, perception, exposure, infectivity, incidence, severity, preventability potential, potential hazard, potential exposure, number of hospitalizations, number of deaths, response, and infectivity. (Kemmeren, et al. 2006)

In 2006, RIVM published the document "*Priority Setting of Foodborne Pathogens*." This document is intended to be a tool for decision makers to establish priorities over the main pathogens that affect public health in the Netherlands in order to be able to control, prevent and supervise the situation. Scientists involved in the development of this document believe that in order to have effective policies, is essential to determine which are the pathogens that create more damage to society. The prior study included the following seven pathogens: *Thermophilic Campylobacter spp. Shinga-toxin* producing *Escherichia coli O157, Salmonella spp.* Norovirus*,* Listeria Monocytogenes *and* Toxoplasma Gondii*.*

The pathogens are compared using the following criteria:

- Disease Burden
- Cost of illness
- Food attributable fraction
- Trends
- Involved food products
- Perception

The *Disease Burden* is an index calculated to measure the impact of an illness in the patients' life and it is calculated using a population of patients. It is measured using the Disability Adjusted Life Year (DALY) and it depends on Years of Life Lost due to mortality (YLL) and the number of Years Lived with a Disability (YLD), which includes a weight that depends on the severity of the disability.

The Cost of Illness is calculated based on the Direct Health care Costs (DHC) and the Direct Non-health care Costs (DNHC) and the Indirect Non-health Costs (INHC). The Cost of illness includes evaluation of doctors, hospitalization, medication, rehabilitation, travel costs, diapers as well as the value of production lost to society due to the illness due to temporary, long term or permanent absence of work.

Notice that the discussion and conclusions of the previous study do not give information about the routes of infection; in fact the cases related with food ingestion can not be compared to the cases of illnesses transmitted abroad or by animal contact. Being able to identify the possible contamination routes allow the decision maker to go deeper and construct better and more accurate policies providing more effort and recourses in specific areas.

The aim of this project is to determine the fraction of the total health burden and cost that can be attributable to each of the possible contamination pathways, and within the food ingestion cases, the fraction for each food category. Notice that this fraction can be understood as the probability of transmission of certain disease by a specific route or ingestion of a particular food type.

Both, the pathways and the food categories are collectively exhaustive and mutually exclusive. In the case of the pathways, contamination does not take place through a different route than the ones defined in Table 1. Additionally, contamination occurs through one of the pathways but not through more than one pathway simultaneously. Similarly, cases due to food ingestion are originated by one and only one of the food categories described in Table 2.

In general, pathogens may be transmitted by contaminated food, water, soil, air, contact with a sick person, and contact with a contaminated animal. The exposure pathways are defined in five groups as follows; the name and explanation can be found in Table 1. The last pathway is defined because of the nature of the study. In fact the causes of transmission abroad are the same that inside The Netherlands, but for policy-making it is important to know what proportion of the illnesses are effect of other countries' sanitary problems.

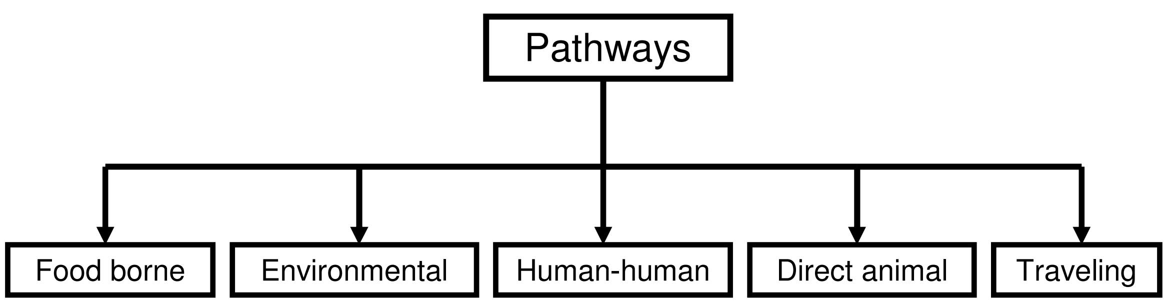


Figure 1

Food borne	Transmission through food that is contaminated when it enters the kitchen or during preparation (e.g. by food handlers).
Environmental	Transmission through contaminated water (drinking water, recreational water), soil, air or other environmental media (fomites*).
Human-human	Transmission from person to person by the fecal-oral route.
Direct animal	Transmission by direct contact with live animals including pets, farm animals, petting zoos etc.
Abroad	Cases when exposure takes place by any of the above pathways during foreign travel.

* Inanimate objects or substances capable of absorbing, retaining, and transporting contagious or infectious organisms

Table 1

Additionally, it is possible to make a finer estimate of the fraction of the pathogens due to specific food products. Having these fractions allows the decision makers to pay special attention to the more dangerous food industries when fighting against and controlling outbreaks of a certain pathogen. For this purpose, the food categories in Table 2 were defined.

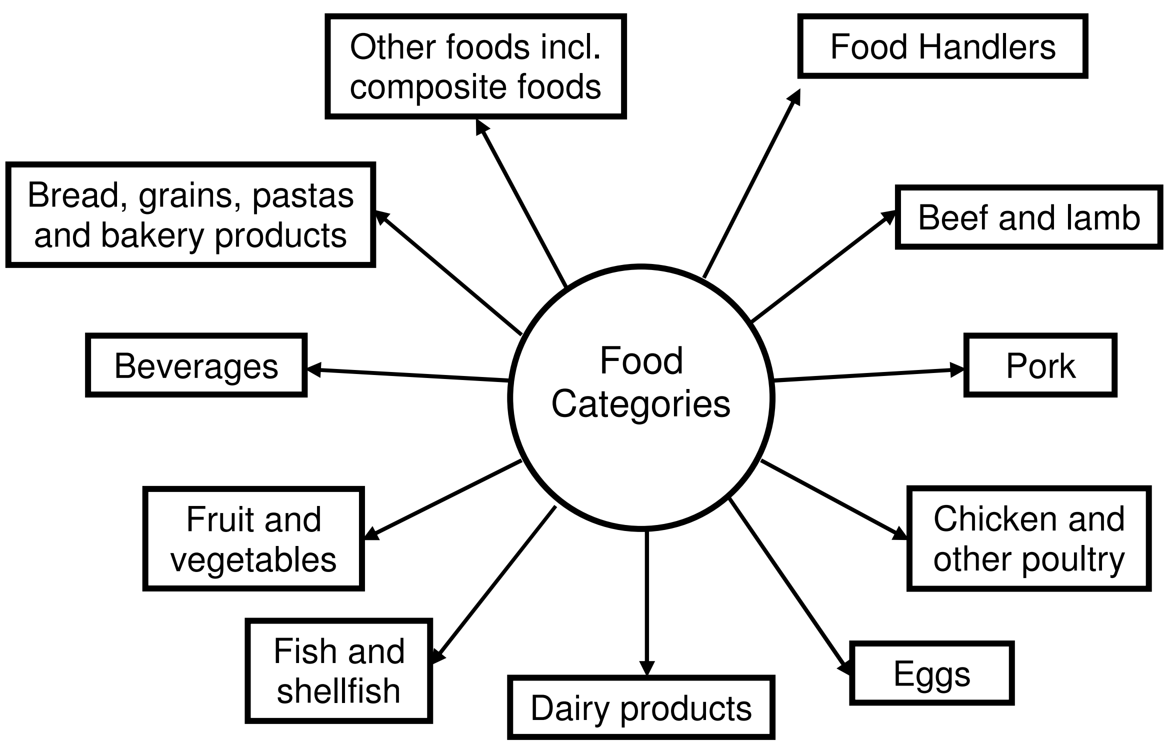


Figure 2

Beef and lamb	Beef, veal, lamb and mutton. Includes processed and non-processed beef products (sausages, filet américain, hamburgers etc.).
Pork	Includes processed and non-processed pork products (susages, luncheon meats etc.).
Chicken and other poultry	Includes duck, goose, ostrich and turkey. Includes processed and non-processed poultry products (chicken wings, marinated chicken, confits etc.)
Eggs	Including egg products
Dairy products	Milk, cheese, butter, cream etc.
Fish and shellfish	Includes all finfish, shellfish (mussels, oysters, etc.) and crustaceans (lobster, shrimps etc.).
ruit and vegetables	Includes (mixtures of) vegetables that are consumed raw or cooked.
Beverages	Includes all non-alcoholic and alcoholic beverages, except milk.
Bread, grains, pastas and bakery products	Includes pastries
Other foods incl. composite foods	Includes all categories not listed above (e.g. nuts, oils, confectionery, spices) and all foods that are sold to the consumer as a composite of two or more of the above categories (e.g. pizzas, lasagna, nasi-goreng, sandwiches).
Infected humans or animals	Includes food handlers, vermin, pets etc.

* Contamination is assigned to the food category (or other vehicle) as it enters the kitchen.
Defined by Arie Havelaar et al

Table 2

It is expected that by the end of this project, it would be possible to have a fraction of the cases due to the different pathways and the food categories for a given pathogen. The pathogens included are listed in Table 3. The sum of the fractions of the five pathways as well as the sum of the eleven food categories will be equal to one because of the assumptions that these are the only possible pathways and food categories respectively.

Campylobacter spp.
STEC O157
Non-O157 STEC
Listeria monocytogenes
Mycobacterium avium
Salmonella spp.
Bacillus cereus toxin
Clostridium perfringens toxin
Staphylococcus aureus toxin
Enterovirus
Hepatitis A virus
Hepatitis E virus
Norovirus
Rotavirus
Cryptosporidium parvum
Giardia lamblia
Toxoplasma gondii

Table 3

CHAPTER 3: EXPERT JUDGEMENT

In general, statistical data is an important base to build forecast, calculate estimates or support decisions. Unfortunately it is common to find real life examples where data is not always available and complete. One possible solution to this situation is Expert Judgment.

Expert Judgment is a methodology to obtain information from people who know about a certain subject, instead of drawing conclusions from data. The idea of behind this tool is to rely on experts' knowledge and understanding of a particular subject to substitute the missing information. One of the final objectives of Expert Judgment is to reach rational consensus among a group of experts. (Cooke, 1991).

The Classical Method for Expert Judgment is a methodology to process data given by experts in order to reach a rational conclusion. Experts are supposed to provide their assessments through an elicitation giving quantiles from the unknown distribution of variables under study; experts are usually asked to give the 5%, 50% and 95%. The data collected is used to build a probability distribution that represents the uncertainty and the knowledge that the group of experts collectively has. This distribution is called the Decision Maker (DM) distribution.

In order to understand how the Decision Maker distribution is constructed is important to make a distinction among the elicitated variables. Along with the variables for which there is not data, there are a set of variables for which the true value is available for the analyst. Knowing the value of these variables enables to score the experts' assessments with respect to calibration and information. (Cooke and Bedford, 2001). Actually, the classical model is a weighted average model, where the weights are calculated based on the *calibration* and *information* scores. Basically, the weights are used to combine expert distributions according to their performance. Intuitively, the experts that made better assessments regarding the seed variables will have more influence in the Decision Maker distribution.

Calibration

Calibration is a measure for statistical likelihood. An expert will have a good calibration score if he or she gives quantiles such that 5% of the realizations are less than the 5% quantile, 45% of the realizations are between the 5% and 50% quantiles, and so on. The idea is to measure how similar the empirical distribution and the experts' uncertainty distribution are. See (Cooke, 1991).

The calibration score is a numerical value calculated for each of the participating experts. Assuming the usual scenario, where experts give 5%, 50% and 95% quantiles, there are going to be 4 inter quantile intervals. Vector p is defined such that p_i denotes the probability that a realization of the variable falls in the corresponding inter quantile interval. According to the assumption, vector p would be equal to $p = \begin{pmatrix} 0.05 & 0.45 & 0.45 & 0.05 \end{pmatrix}$. In general, if an expert is asked to give n quantiles, then p will have the corresponding probabilities of $n+1$ inter quantile intevals.

Let $s = (s_1 \quad s_2 \quad s_3 \quad s_4)$ be the empirical probability vector which contains the relative frequencies that fall in the corresponding inter quantile inrevals. For example s_1 is equal to the number of realizations that are less than or equal to the 5% quantile, s_2 is equal to the number of realizations that are less than or equal to the 50% quantile and greater that the 5% quantiles divided by the total number of realizations. s_3 and s_4 are defined similarly.

A well calibrated expert should give intervals for which vector s would be similar to vector p. The *Relative Information* $I(s;p)$ is used to measure how similar or how close the two vectors are.

$$I(s;p) = \sum_{1}^{4} s_i \ln(\frac{s_i}{p_i})$$

The relative information is equal to 0 if and only if vector s is identical to vector p. This is of course the ideal scenario. A well calibrated expert will have a relative information score close to 0. Assume that there are N seed variable. For large numbers of N, then the distribution of the product of $2N$ and the relative information $2NI(s;p)$, can be approximated by the Chi-square distribution with n degrees of freedom (3 for this case). (Bedford and Cooke, 2001).

Usually, one realization is available for the seed variables. This value can be understood as an independent sample from the distribution with quantiles equal to the ones given by the expert.

Finally, the calibration score is defined as follows

$$C = 1 - \chi_n^2\left(2NI(s;p)\right).$$

Where χ_n^2 is the cumulative distribution of the Chi-square with n degrees of freedom. Then considering N seed variables, the calibration score is an approximation of the probability of a having a Relative Information less than or equal to $I(s;p)$. A poor calibrated expert will have a calibration score close to 0. On the other hand, a perfectly calibrated expert will have a relative information to 0 which would lead to a calibration score of 1. Doing a comparison with hypothesis testing, it is possible to define the hypothesis that expert's assessments are accurate. Then the calibration score can interpreted as the p-value at which this hypothesis would be rejected.

Information

Intuitively, an expert that gives quantiles with a very broad inter quantile interval is less informative than one that is given narrow intervals. This idea is formalized using the information score which can be interpreted as a measure of the degree to which the distribution is concentrated (Cooke and Goossens, 2000). Information is measured with respect to a background measure; the uniform and log-uniform distributions are commonly used. The background measure is the either the uniform of log-uniform distribution over an intrinsic range for each variable which is defined as smallest interval that contains all quantiles given by experts plus a $k\%$ overshoot. Even though the value of k is chosen by the analyst, the default value is 10. Note that the relative information with respect to a background measure is measured for both, the variables of interest and the seed variables; the information score does not depend on the value of the true realizations of the seed variables.

Then relative information I of an expert for a given variable is defined as follows.

$$I = \sum_{1}^{4} p_i \ln\left(\frac{p_i}{r_i}\right)$$

Where p is the same as defined above and r_i are the background measures of the corresponding intervals. Finally, the information score for each expert is calculated as the mean of the information scores of all variables. Higher values of information scores are preferred over lower values. Between the calibration score and the information score, the former is more relevant compared to the later.

Decision Maker

As stated before the information and calibration scores are defined in order to combine experts' assessment in a rational and structured way. The classical model is a method that calculates a weight for each of the participating experts in order to combine their assessments using a weighted average. As previously, explained an ideal expert would have high calibration and information scores. Therefore those experts whose calibration and information scores are high are going to have a higher weight and their assessments will have a bigger influence in the Decision Maker.

The weights are defined to be proportional to the product of the information and calibration scores. The weight for expert e is equal to the product to information, the calibration scores and the following indicator function. But yet α has to be defined by the analyst. The following are two possible methods to do so.

$$1_\alpha(x) = \begin{cases} 1 & if\, x < \alpha \\ 0 & otherwise \end{cases}$$

$$w_\alpha(e) = 1_\alpha(Calibration) \times Calibration(e) \times Information(e)$$

The first technique is called *global weight Decision Maker* and it chooses a value for α that maximizes the combined score for the Decision Maker. This means that the α will be equal to the result of maximizing the product of the calibration and information score for the Decision Maker distribution.

The second method, called the *item weight Decision Maker*, which is a variation of the above, defines the weights using the information score for each item instead of the average value. Then the weight depends not only on the expert e, but also on the item i. The item weight Decision Maker for each item i is defined by the following equation:

$$w_\alpha(e,i) = 1_\alpha(Calibration) \times Calibration(e) \times I\left(f_{e,i} \middle| g_i\right)$$

In this case, α is equal to the value that maximizes the product of the calibration score of the item Decision Maker and the information score of the item Decision Maker. For formal definition see Cooke, 1991.

Excalibur

Excalibur is software that enables to apply the concepts presented above. The program was designed based on the methodology included in “Experts in Uncertainty” (Cooke, 1991). All the results included in this document have been processed using this tool.

CHAPTER 4: PROBABILISTIC INVERSION

PROBABILISTIC INVERSION

Based on the methodological assumptions, expert judgment can be applied whenever the variables under consideration can be theoretically measured or observed. However, there are some complex situations where the variables of interests can not be measured nor observed; therefore experts are not able to give quantiles nor any smart approximation of the variables or interest. Instead of observable quantities, an analyst can find an observable variable that is related to the values of interest through a function. For example, the analyst might be interested in a parameter of a physical model that is not observable in the field. If the function relating the parameter and an observable variable is known, then it is possible to find some information about the parameters. In that case, experts are able to give quantiles of the distribution of the observable variable. Based on that information a method called probabilistic inversion can be applied to obtain data from the parameter's distribution.

As it is possible to invert a function at a value in its range, it is possible to invert a function at a random variable as well. Then, it is feasible to find a distribution for the value of interest by elicitating not the variable itself but other quantities as long as both are related with a measurable function. When inverting a function at a random variable the result is a distribution of the random variable.

Definition

Let X and Y be two random vector in $\Re^n$ and $\Re^m$, respectively; and F a measurable function from $\Re^n$ to $\Re^m$. If $F(x) = y$, then $x \in \Re^n$ is the inverse of $y \in \Re^m$ under F. Correspondingly, if $F(X)$ has the same distribution as Y, then X is the probabilistic inverse of Y under F.

The probabilistic inversion problem can be defined as follows. Assume that vector Y is the vector of the observable variables, and that the physical model relating the variables and the parameters is given by the set of functions F. Then the problem consist in finding the joint distribution of random vector X such that $F(X) = [F_1(x) \quad F_2(x) \quad \ldots \quad F_n(x)]$. Has the same distribution as random vector Y. The random vector Y represents the partially known distribution of the observable variables.

Note that the problem described above may or may not have absolution. Furthermore, in case of feasibility there might exist multiple solutions; in that case it is possible to determine the best, among all possible solutions. In the case of infeasible, an approximation of the random vector can be derived. (Kurowicka and Cooke, 2002).

Iterative algorithms can be used to solve probabilistic inversion. The models considered in the present analysis are Iterative Proportional Fitting (IPF) and Parameter Fitting for Uncertain Models (PARFUM) which are algorithms based on sample re-weighting, which make them very simple to implement. Both methods take as a starting point, a set of quantiles known by the analyst. This quantiles might by extracted from an Expert Judgment ellicitaton, namely this values can be the corresponding quantiles of the Decision Maker distribution. The objective of probabilistic inversion is to find a distribution of minimum information with these same quantiles.

In order to understand the two methods, consider the following example. Assume that a Decision Maker distribution has been built for two random variables Y_1 , Y_2 and the 5%, 50% and 95% quantiles are chosen to be the representation of these distributions. Consider the following vectors for random variables Y_1 and Y_2 respectively, $\left(q_{1;5\%} \quad q_{1;50\%} \quad q_{1;95\%}\right)$ and $\left(q_{2;5\%} \quad q_{2;50\%} \quad q_{2;95\%}\right)$.

The first step is to choose a suitable distribution for generating samples. Apparently, the choice of this distribution is a simple step, since the objective is to find any distribution that is defined in the same interval as the elicitated variable. Usually this interval is defined by the physical meaning or theoretic values of the variable. However, these distributions must be chosen such that each and all inter quantile interval has some samples that fall inside them.

Once the distribution is selected, the next step is to sample the random vector. For the present example a sample of 150 observations was generated to build a contingency table. Figure 3. The sample is generated using gamma distribution for both variables; the first with parameters $\alpha = 1$ and $\beta = 1$, the second with parameters $\alpha = 1$ and $\beta = 2$. Furthermore, assume that there exists a set of constraints in the form of the 5%, 50% and 95% quantiles, which were used to build the contingency table. Note that the sum of the rows and columns are not equal to the theoretic corresponding inter quantile mass, this is $\left(0.05 \quad 0.45 \quad 0.45 \quad 0.05\right)$.

Now it is possible to determine how many samples are between the 0% and 5%, between 5% and 50% , between 50% and 95% and between 95% and 100% quantile, for each of the n samples. This is done be determining in which inter quantile interval, each of the n elements is in.

0.0333	0.0067	0.0133	0.0133		0.0667
0.1733	0.0400	0.1000	0.0267		0.3400
0.0800	0.0133	0.0667	0.0133		0.1733
0.1867	0.0467	0.1533	0.0333		0.4200

Figure 3

The objective of both iterative methods presented, is to find a weight for each of the samples such that the quantile constraints are satisfied. Translated to this example, this means that the sums of the columns and rows of the contingency table above are equal to the vector $\begin{pmatrix}0.05 & 0.45 & 0.45 & 0.05\end{pmatrix}$. This is equivalent to finding weights such that the marginal distributions have the same quantiles given by the Decision Maker distribution.

These weights are used as probabilities to re-sample and in this way, obtain a distribution that satisfies, or is close to the fit the given quantiles. This step was done using the UNICORN software. For further information see Kurowicka and Cooke, 2006.

Iterative Proportional Fitting IPF

Suppose that we have the sample describe above, and as a result, the contingency table in Figure 3. In order to fit the margins, all values of each column are multiplied by a factor equal to the theoretical inter quantile mass divided the actual total sum of the column. Similarly, each element of the same row are multiplied by the corresponding mass and then divided by the sum of the row. This is done to all columns and then to all rows in the table; this constitutes one iteration of IPF.

In the example each element of the first column is multiplied by $0.05/0.4733$. Figure 4 shows the resulting values after all columns have been multiplied by its corresponding factor. Notice that after the multiplication, the column sums are equal to the desired probability mass. The second, third and fourth column are multiplied by $0.45/0.1067$, $0.45/0.333$, $0.05/0.0867$ respectively. Following the example, the elements of the first, second, third and fourth row are multiplied by $0.05/0.0573$, $0.45/0.03374$, $0.45/0.1624$ and $0.05/0.4428$ respectively. The results after IPF first iteration is in Figure 5.

0.0035	0.0281	0.0180	0.0077
0.0183	0.1688	0.1350	0.0154
0.0085	0.0563	0.0900	0.0077
0.0197	0.1969	0.2070	0.0192

0.0573
0.3374
0.1624
0.4428

Figure 4

0.0031	0.0245	0.0157	0.0067
0.0244	0.2250	0.1800	0.0205
0.0234	0.1559	0.2494	0.0213
0.0022	0.0222	0.0234	0.0022

0.05
0.45
0.45
0.05

Figure 5

The method continues iterating until convergence. For this example, the solution is presented in Figure 6. However not all problems are feasible, and in those cases convergence is never attained while using IPF (Kurowicka and Cooke, 2006)

0.003	0.026	0.015	0.007		0.050
0.023	0.235	0.172	0.020		0.450
0.022	0.165	0.241	0.021		0.450
0.002	0.023	0.022	0.002		0.050

Figure 6

Iterative Parameter fitting for uncertain Models PARFUM

Similarly to IPF, the input for Iterative PARFUM is a sample of random vectors and the quantiles assessed by the experts. The difference between these two methods is that while IPF changes the weights for each sample for the columns to fit the correct mass and then for the rows, iterative PARFUM fits both columns and rows simultaneously. This is done by replacing each element of the table with the average of the values obtained when fitting the column and fitting the row sums separately.

Recall the example previously solved by IPF. The first step is to calculate the corresponding values to fit the columns and row separately of the original table (Figure 4). The calculations fitting the column and the rows separately are in Figure 5. The next step is to calculate the average of these two values for each of the elements in the contingency table. See Figure 8. This constitutes one iteration of PARFUM. The process is done until convergence is obtained; PARFUM will always converge. (Kurowicka and Cooke, 2006.) For the example, the final values obtained are presented in Figure 9.

0.0035	0.0281	0.0180	0.0077		0.0573
0.0183	0.1688	0.1350	0.0154		0.3374
0.0085	0.0563	0.0900	0.0077		0.1624
0.0197	0.1969	0.2070	0.0192		0.4428
0.05	0.45	0.45	0.05		

0.0250	0.0050	0.0100	0.0100		0.05
0.2294	0.0529	0.1324	0.0353		0.45
0.2077	0.0346	0.1731	0.0346		0.45
0.0222	0.0056	0.0183	0.0040		0.05
0.4843	0.0981	0.3337	0.0839		

Figure 7

0.0143	0.0166	0.0140	0.0088
0.1239	0.1108	0.1337	0.0253
0.1081	0.0454	0.1315	0.0212
0.0210	0.1012	0.1126	0.0116

0.0537
0.3937
0.3062
0.2464

Figure 8

0.0015	0.0295	0.0140	0.0051
0.0188	0.2432	0.1690	0.0191
0.0296	0.1446	0.2506	0.0251
0.0001	0.0327	0.0165	0.0007

0.0500
0.4500
0.4499
0.0500

Figure 9

The superiority of any of these two strategies is not clear. IPF is often preferred over PARFUM whenever the problem is feasible. On the other hand, when the problem is unfeasible PARFUM has shown better results. (Kurowicka and Cooke, 2006.)

Once either of these two methods is applied, a weight for each of the observations is available. The weight is calculated based on the resulting values after the iterative method and the number of observations that fall in each interval. The generated sample is used to re-sample using theses weights as probabilities of occurrence, ensuring that this distribution fits the quantiles given by the experts. For formal definition see Kurowicka and Cooke, 2006.

In the present project, Probabilistic Inversion is used to estimate the probabilities of contamination for specific pathways and food categories. The sampled vector will be of dimension 5 and 11, for the pathways and food categories respectively.

Additionally, the elements of both vectors are going to be sampled such that the values are between 0 and 1 and the sum of the elements it is equal to 1. This represent the assumption that the pathways are Collectively Exhaustive and Mutually Exclusive i.e. these options are the only possible pathways to get contaminated and a person is contaminated by either one of the pathways or food categories but not by more than one simultaneously.

CHAPTER 5: MODELS

The Experts

Given the nature of the study, a good choice of expert is very important in order to have reliable and meaningful results. The experts invited to make part of this elicitation were contacted and chosen by Dr. Ir. Arie H. Havelaar from RIVM. The group has members from both the industry and research. The idea is to have a panel of experts of a broad range of disciplines; specialization of the experts includes microbiology, biochemistry and Medical Biochemistry.

Experts are members of RIVM, NIZO, VION, the Food and Consumer Product Safety Authority, Wageningen University and University of Amsterdam. NIZO, an independent research organization focused in advising food producers and handlers in flavor, texture, processing, health and food safety in dairy products. The main field of study in VION is meat including processing, food safety and quality.

Some experts are professors in the food and food production in Wageningen University and therefore might have very broad perspective; other experts have studied a particular food, for instance chicken and poultry, for several years and have a deeper but narrower knowledge. As a result, experts were encouraged to choose not to answer a question regarding a pathogen or food category that he or she has no deep understanding. Therefore the number of experts participating per pathogen varies. The pathogen with the biggest number of experts has 12 participating experts and the least number of experts per pathogen is 2.

Originally, 37 experts were invited and 28 agreed to participate. After the questionnaires were sent, 2 experts said that their knowledge in the subject was not enough and did not answer, while 10 never sent their assessments. As a result, 16 experts participated in the elicitation.

The Elicitation

In the elicitation, experts were asked to give an interval which contained the probability of transmission through a particular pathway or ingestion of a food group with 90% certainty. For each pathway, the experts filled an interval containing the probability that a case of a given pathogen was transmitted through this pathway. Similarly, for each food group, the experts provided an interval containing the probability that a case of a given pathogen was transmitted through ingestion of elements of this food group. See Appendix B for an example of the questions included in the elicitation. Asking experts for intervals reduces respondents fatigue and actually allows them to answer questionnaires for more pathogens.

Since the experts participating in this exercise have different backgrounds -some of them have general knowledge while others have very specific expertise in a specific pathogen or food category- each expert was asked to choose the questionnaires that they felt confident answering. For each pathogen in the study there are two questionnaires: one regarding different contamination pathways and other regarding contamination by ingestion of specific food category.

For both questionnaires, experts were expected to give an interval –with 90% certainty- for the probability of contamination through each pathway or food category. For each pathway, the expert will fill in an interval which contains the probability that the pathway is the route of the given pathogen. Similarly, for each food category, experts filled in an interval which contains the probability that the food category is the carrier of the given pathogen. Appendix B includes an example for Salmonella of the questionnaires sent to the experts.

The elicitation for the probabilistic inversion was done entirely by email. After sending the invitation, experts were to answer which questionnaires they intended to complete. Thirty seven experts were invited to participate in the study, but finally only sixteen actually participated.

Methodology

After gathering the data from the experts, namely the intervals for the probability of contamination through each pathway and food category, the distributions based on all experts' assessments were build. These distributions were constructed by giving all experts same weight in the final distribution, this distribution is going to be referred as the Equal Weight Decision Maker (EWDM). From this distribution, it is possible to get the 5% and 95% quantiles of each of the probabilities, which constitute one of the inputs for Probabilistic Inversion.

The next step is to choose the distributions to generate the sample for Probabilistic Inversion. The sample distribution has to meet two characteristics. First, the values of the random variable have to meet the physical constraints of its meaning in the application. In this application, the ellicitated variables are probabilities, therefore the values of the random variables have to be between 0 and 1. Then sample distributions will have to be defined in this interval. Second, it is needed that after sampling, there are some samples in every inter quantile section. This does not mean that the contingency table can not have empty cells, but that a whole row or column can not be empty.

Particularly in this example, since the variables are probabilities which are collectively exhaustive and mutually exclusive then there is an additional constraint: the sum of all values of the random vector should be equal to one. Then the selection of the sample distribution is equivalent to finding the distribution defined in the interval [0, 1] such that the sums of the values in each sample have to be equal to one. In the case of the pathways, the objective is to find joint distribution of a vector of dimension 5, while for the food categories the vector is of dimension 11.

In order to introduce the constraint that the probabilities sum to one, two approaches were considered:

- Sample *n-1* uniform (0,1) random variables $U_1, U_2, \ldots U_{n-1}$, and define the nth variable to be equal to $U_n = 1 - \sum_{i=1}^{n-1} U_i$. Naturally, the sum of the n variables is equal to one. Taking only the samples for which U_n is positive, would be a suitable input sample for Probabilistic Inversion. However, the number of samples needed to get a reasonable number of samples that meet this requirement is very big. Additionally, the choice of making the nth variable dependent on the other seems arbitrary. It is also possible to meet the condition of sample as desired by defining the first or any other variable as 1 minus the sum of the others. A very important question arises then, does this arbitrary choice has an effect on the results?

- Sample *n* positive value random variables $U_1, U_2, \ldots, U_n$ and define $T = \sum_{i=1}^{n} U_i$. The random vector $V = \left(U_1/T, U_2/T, \ldots U_n/T\right)$, meets the condition of having the sum of its elements equal to one. In this case, all samples meet the condition and all *n* variables are generated equally. In the present study, this choice was preferred, and all the models are done using this procedure.

The samples were generated using Unicorn, software developed at Delft University of Technology. For details visit the group website http://dutiosc.twi.tudelft.nl/~risk/.

The next step is to choose the distribution and parameters to sample the random variables $U_1, U_2, \ldots U_n$. The natural choice is a uniform distribution between 0 and 1, because the variables represent probabilities. However, after dividing each variable by the total sum, the elements of the resulting vector do not take values bigger than 0.8 6 for the case of pathways and not bigger than 0.45 in the case of the food categories. This represents a problem since the 95% quantile given by the experts exceed these values for most to the pathogens. Using 65000 samples the intervals obtained when sampling 5 and 11 variables are in Table 4 and Table 5 respectively. Figure 10 and Figure 11 are the cobweb plots of 200 samples of using the uniform distribution.

Variable	Min(Variable)	Max(Variable)
u1	1.17E-05	0.78287
u2	1.07E-05	0.81057
u3	4.37E-05	0.8666
u4	1.43E-05	0.83007
u5	9.62E-06	0.81099

Table 4. Minimum and maximum values of Ui using the uniform distribution for 5 variables

Variable	Min(Variable)	Max(Variable)
u1	4.45E-06	0.39989
u2	4.17E-06	0.3571
u3	4.1E-06	0.35309
u4	5.33E-06	0.32387
u5	3.84E-06	0.39654
u6	1.84E-05	0.40201
u7	5.12E-06	0.33225
u8	5.87E-06	0.36445
u9	4.52E-06	0.33709
u10	4.14E-06	0.43426
u11	5.26E-06	0.3312

Table 5. Minimum and maximum values variables Ui using the uniform distribution for 11 variables.

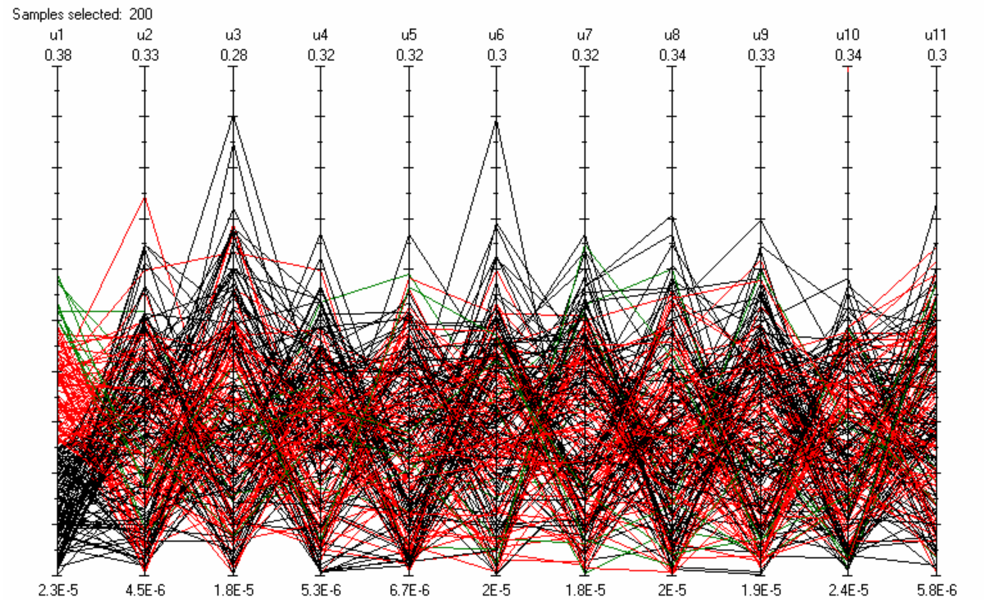


Figure 10: Cobweb plot of 200 samples using uniform distribution for 11 variables.

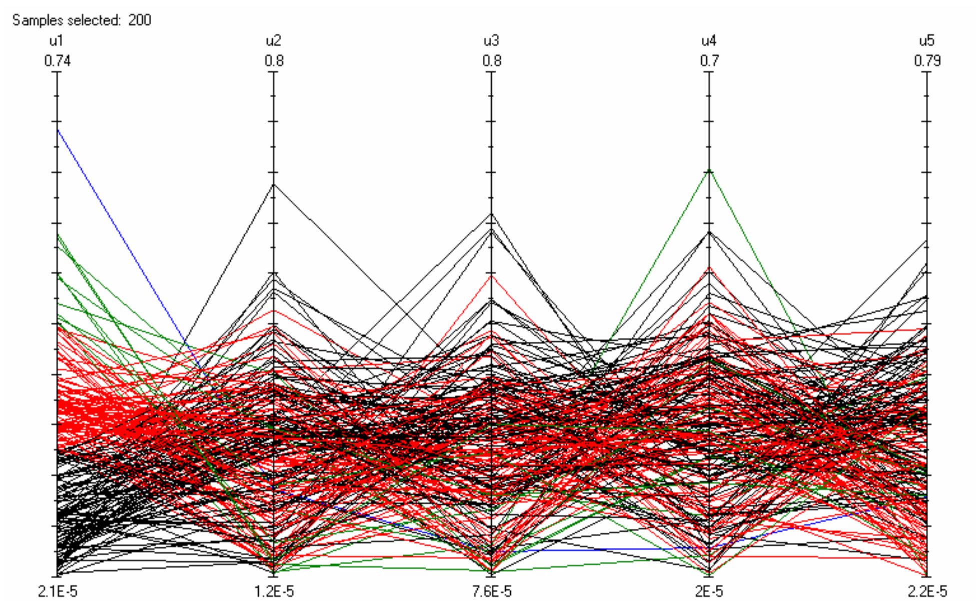


Figure 11: Cobweb plot of 200 samples using uniform distribution for 11 variables

It is important to consider that in this particular application there will be pathogens for which a specific pathway or food category will be dominant, meaning that it will be the main cause of contamination. Therefore, the choice of the uniform distribution is not appropriate.

At this point any distribution defined in the real numbers is a possible candidate to do the sampling step. Since the actual sample is equal to the random variable divided by the total sum, it is not possible to foresee the range where these numbers are going to be.

However, there is a possible distribution of a random vector that may give a guide in this process. Let X be a random vector, where each of the elements are independent and have a gamma distribution with scale parameter equal to 1. $X \sim Gamma(shape = \alpha_i, scale = 1) \quad for \quad i \in \{1,...n\}$ Then, the random vector $Y = \left(X_1 / T, X_2 / T, \ldots X_n / T \right)$, where $T = \sum_{i=1}^{n} Xi$ has a Dirichlet distribution with parameters $\alpha_1, \alpha_2, \ldots \alpha_n$.

Identifying the random vector distribution is an advantage because it is possible to calculate its expected value and variance, which can be useful in determining the parameters to fit the constraints given by the experts. Then the choice for the sampling distribution was to use the Gamma distribution.

Let $\alpha_0 = \sum_{i=1}^{n} \alpha_i$, then the expected value of X and its variance given α, are:

$$E\left[X_i \middle| \alpha \right] = \frac{\alpha_i}{\alpha_0}$$

$$Var\left[X_i \middle| \alpha \right] = \frac{\alpha_i \left(\alpha_0 - \alpha_i \right)}{\alpha_0^2 \left(\alpha_0 + 1 \right)}$$

Sample Distributions

Since the random vector of the distributions is distributed Dirichlet, we can calculate the mean and variance. Because of the nature of the items ellicitated in this project there were cases when only one of the items had to have higher values and the other could be low. Then the solution to that situation was to change the parameters of the gamma to increase the variance of the particular item.

A set of parameters was considered to be suitable for sampling if there were no empty intervals when doing Probabilistic Inversion. Furthermore, even when there were no empty intervals and the results with IPF and PARFUM were not satisfactory, (meaning that the fitting was poor) the sample distribution was changed as well.

Basically, the parameters were chosen by trial and error as follows. The first attempt consisted to sample the gammas with parameters equal to one. If there were inconvenient as the ones explained before, a Gamma with scale parameter equal to 1 and shape parameter equal to 0.5 was used. The search continued by consecutively changing the parameters. As a specific pathogen presented empty intervals when running probabilistic inversion, the next option or next combination of parameters was used.

- Gamma with both shape and scale parameter equal to 1.
- Gamma with scale parameter equal to 1 and shape parameter equal to 0.5
- Gamma with scale parameter equal to 1 and shape parameter equal to 0.3
- Gamma with scale parameter equal to 1 and shape parameter equal to 0.2
- Gamma with scale parameter equal to 1 and changing the shape parameter in order to have a broader interval for a specific variable. The parameters were calculated to maximize the variance of the desired variable while the other parameters were positive. The values used in these cases are included in Table 6.

Vi	alfa i	E.VALUE	VAR
FOOD	0.5	0.2	0.045714
ENVIROMENT	0.5	0.2	0.045714
SICK	0.5	0.2	0.045714
ANIMAL	0.5	0.2	0.045714
ABROAD	0.5	0.2	0.045714

Variable	Min(Variable)	Max(Variable)
u1	7.34E-17	1
u2	1.76E-46	1
u3	7.19E-41	1
u4	1.63E-46	1
u5	4.41E-47	1

a) Parameter values when maximizing variance of item

Vi	alfa i	E.VALUE	VAR
BEEF	0.618035	0.381966	0.09017
PORK	0.1	0.061803	0.022148
CHICKEN	0.1	0.061803	0.022148
EGGS	0.1	0.061803	0.022148
CAIRY	0.1	0.061803	0.022148
FISH	0.1	0.061803	0.022148
F&V	0.1	0.061803	0.022148
BEVERAGES	0.1	0.061803	0.022148
BREAD	0.1	0.061803	0.022148
COMPOSITES	0.1	0.061803	0.022148
HUM/ANIM	0.1	0.061803	0.022148

Variable	Min(Variable)	Max(Variable)
u1	1.6E-47	0.99755
u2	4.61E-47	0.99628
u3	1.95E-08	0.99999
u4	2.75E-47	0.9951
u5	2E-47	0.99389
u6	1E-41	0.99461
u7	3.64E-47	0.99455
u8	2.49E-47	0.99605
u9	2.2E-47	0.99861
u10	2E-47	0.99901
u11	1.18E-47	0.99732

b)Parameter values when maximizing variance of item "BEEF"

Table 6. Values for the parameter of the gamma distribution

After choosing the appropriate sample distribution, a sample of 65,000 observations and the quanties of the equal weights decision maker distributions were used as inputs for Probabilistic Inversion. The default method applied was IPF. However, there are some cases where convergence was not obtained, and as a result PARFUM was applied to find the best approximation.

Then, the final step is to use the weights calculated with Probabilistic Inversion as a probability distribution. A probability file is build where each of the samples generated has a probability of occurrence equal to the corresponding weight. Unicorn was used to re-sample using the described probability file.

The mean values of each distribution after re-sampling are the estimates for the fraction of the total health burden and cost that can be attributable to each of the possible contamination pathways, and within the food ingestion cases, the fraction corresponding to each food category. The sum of the mean values of all the variables after re-sampling is equal to one, which was the desired property.

To illustrate how the methodology was applied in more detail, consider example of Bacillus. For the pathways elicitation, the sample of 65,000 observations was generated using the gamma distribution with scale and shape parameter equal to 1. Nevertheless, this distribution leads to empty intervals, which does not allow the application of IPF nor PARFUM. Consequently, a gamma with scale parameter equal to one and shape parameter equal to 0.5 was used to sample. After having the same results, the gamma with scale parameter equal to 1 and shape parameter equal to 0.3 was used. Once again the same problem was present until the gamma with scale parameter equal to 1 and shape parameter equal to 0.2 was chosen for which all inter quantile interval had mass.

Then IPF was applied using as an input the quantiles of the equal weight distribution based on the assessments given by the 4 experts who participated. These quantiles are presented in the summary table in Table 7 under the column called Decision Maker. Then with the weights calculated by IPF, a probability file can be constructed using these weights as probabilities of occurrence. Later, this probability file is used to re-sample. This step is done using Unicorn as well. At this point it is possible to calculate the quantiles and compare them with the quantiles of the Decision maker distribution. The quantiles of the sampled distribution are included in the column called Re-Sampling. Finally, the mean value of each marginal distribution is the estimate of the fraction of the cases that can be attributed to the corresponding pathway. These values are in the column called Estimate Fraction. A summary table like the one presented in Table 9 is included for each of the pathogens in this study in Appendix A.

Bacillus cereus toxin					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	89.30%	8.09E-01	9.98E-01	6.75E-02	9.98E-01
Environment	1.10%	1.00E-04	4.06E-02	6.49E-05	4.05E-02
Contact with sick person	1.15%	1.00E-04	3.95E-02	9.34E-05	3.99E-02
Direct animal contact	1.12%	1.00E-04	3.95E-02	1.02E-04	4.07E-02
Contamination abroad	7.27%	1.45E-04	9.12E-01	1.35E-04	9.14E-01
	Number of experts	4		Entropy	7.62E+00
	Participating experts			Method	IPF

Table 7

The pathways and the food group were defined to cover all possibilities regarding the route of contamination. However, this does not mean that these categories apply to all pathogens. In fact, for some pathogens contamination through one of the routes described in this classification might be impossible.

As an evidence of this, there were some cases when there was absolute consensus among the group of experts. In these cases, when all experts agreed that the probability of contamination is equal to zero the respective random variable was deleted beforehand. This is the reason why some pathogens have routes with probability equal to zero.

CHAPTER 6: RESULTS

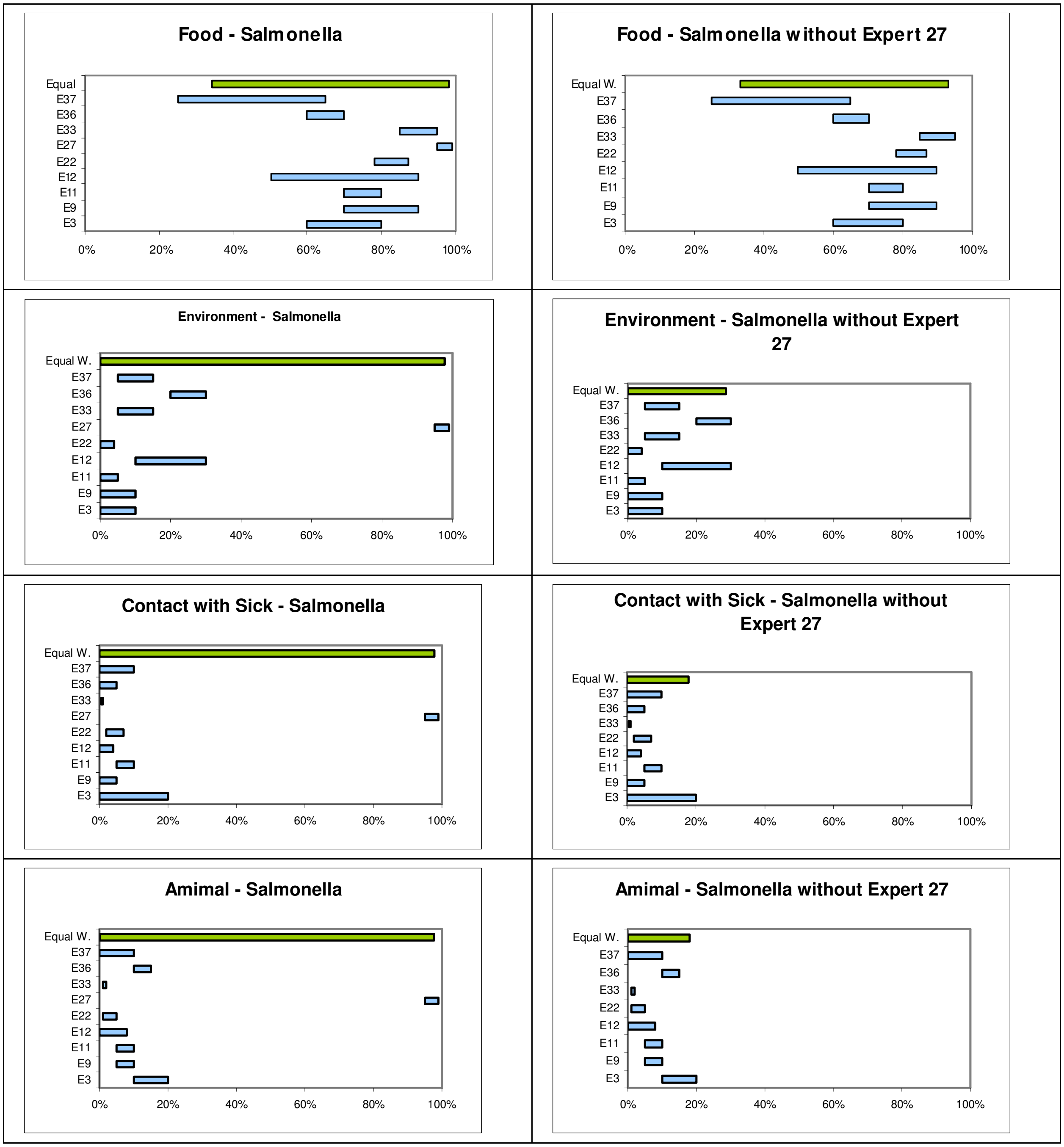
Even though the present elicitation lacks of seed variables which would enable the analyst to filter some experts, based on the data provided by experts, there was enough evidence to consider filtering one of the experts. The lack of seed variables does not allow filtering an expert by any quantitative criteria. On the other hand, after looking closely the experts performance it is clear that one of the experts is not only negatively affecting the Decision Maker distribution but also his interpretation of the questions in the elicitation is not correct.

The following tables include the assessments for Salmonella's pathways. For this particular questionnaire 10 experts participated. Even though, experts don't agree in their assessments, (which is of course expected) expert number 27 gave intervals that are consistently far from the rest of the intervals. Further more, according to his assessments; the probabilities of contamination through all pathways are very high, close to 1. This clearly shows that there was a misunderstanding regarding the questions.

The greatest difference between expert 27 assessments and the others was observable in this example i.e. Salmonella. However, similar situations occurred with his assessments in other pathogens. For all the pathogens for which expert 27 answered the questionnaires, the model was applied including and excluding his assessments. The results changed drastically and in some cases it was not possible to find convergence when he was included. The ranges between the 5% and 95% quantiles for salmonella both, with and without expert 27 are represented in the graphs in Figure 12The corresponding quantiles of the Decision Maker Distribution are included in Table 9. The green bars represent the interval for the Decision Maker distribution and the blue bars are the intervals given by each expert. As a result, expert 27 was excluded of the study because of its inconsistencies and clearly being an outlier.

			EQUAL WEIGHTS		
	FOOD	EVIMENT	SICK	ANIMAL	ABROAD
5%	34.21	0.01908	0.009492	0.04669	2.833
50%	76.47	8.417	3.382	7.043	10.1
95%	98.11	97.79	97.76	97.72	97.55
			WITHOUT EXPERT 27		
	FOOD	EVIMENT	SICK	ANIMAL	ABROAD
5%	33.16	0.01697	0.00736	0.03933	2.749
50%	74.25	7.049	2.835	6.167	9.199
95%	93.27	28.63	17.87	18.06	25.63

Table 8. Comparison of the quantiles for the Decision Maker distribution


Food - Salmonella
Equal
E37
E36
E33
E27
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%
Food - Salmonella without Expert 27
Equal W.
E37
E36
E33
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%
Environment - Salmonella
Equal W.
E37
E36
E33
E27
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%
Environment - Salmonella without Expert 27
Equal W.
E37
E36
E33
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%
Contact with Sick - Salmonella
Equal W.
E37
E36
E33
E27
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%
Contact with Sick - Salmonella without Expert 27
Equal W.
E37
E36
E33
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%
Amimal - Salmonella
Equal W.
E37
E36
E33
E27
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%
Amimal - Salmonella without Expert 27
Equal W.
E37
E36
E33
E22
E12
E11
E9
E3
0%
20%
40%
60%
80%
100%

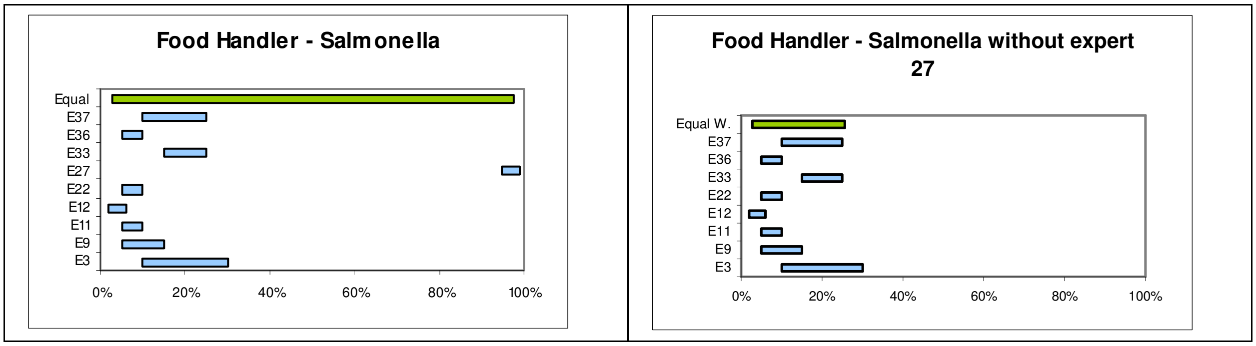


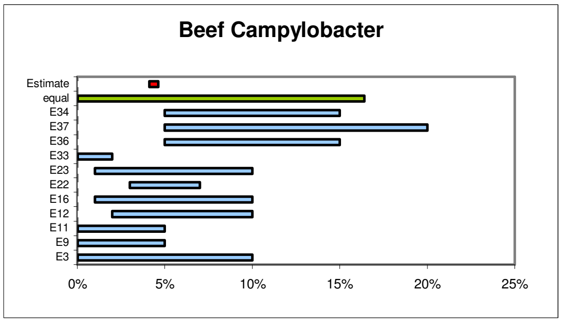
Figure 12

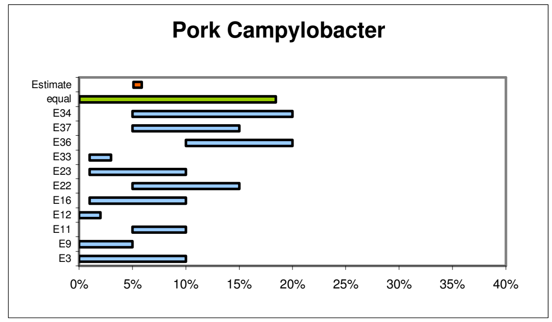
After filtering expert number 27, the results in general are satisfactory. The fit is good enough for the big majority of the pathogens, being slightly better in for the pathways compared with the food categories. This is due to the number of elements. It is simpler for both the assessment and the analysis step, to manage less number of items. For the experts is easier to give estimates for less number of items, because is easier to compare less options in their mind and it is easier to be aware of probabilities that are of bigger magnitude. Naturally, as the number of items increases the comparisons and the assessments are harder because the analysis demands from the expert a more accurate knowledge and a bigger capability of taking all the options in to account.

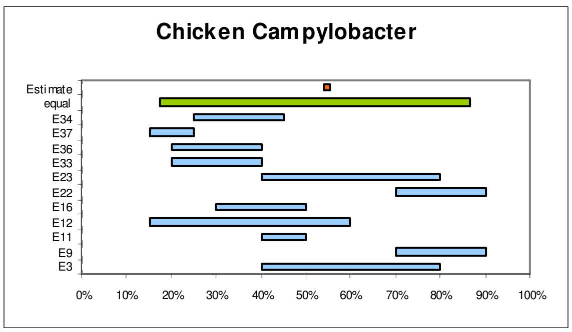
The results fitting the 5% and 95% quantiles for the 17 pathogens are summarized in tables in A.

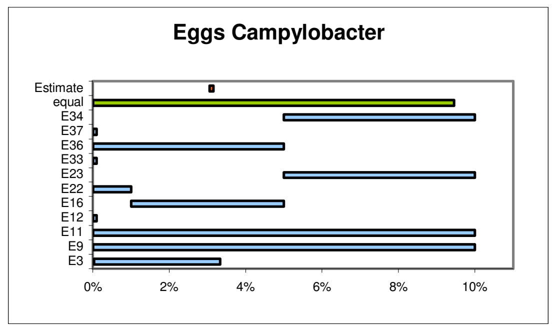
Because of insufficient data, the only way to validate the results presented is to actually have feedback from an expert. At first glance the data looked satisfactory. However, after studying the numbers more closely, the conclusion was that in the cases when a pathway or food category is a main contamination route, the large probabilities were underestimated while the *small* probabilities were over estimated.

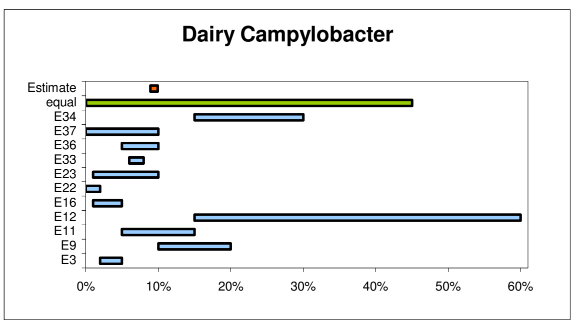
In order to identify the cause of the situation described, some of these pathogens were studied in more depth. The pathogens selected were Campylobacter for food categories. Figure 13 shows in blue the intervals given by each of the experts participating, as well as the interval of the equal weight distribution (in green) and the probability estimate resulting from the probabilistic inversion.

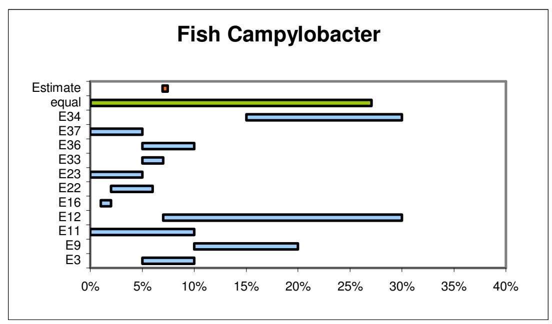

Beef Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
5%
10%
15%
20%
25%

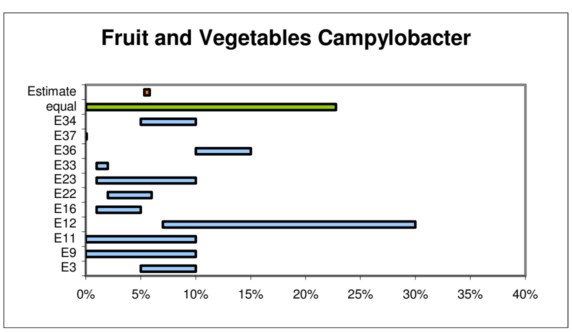

Pork Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
5%
10%
15%
20%
25%
30%
35%
40%

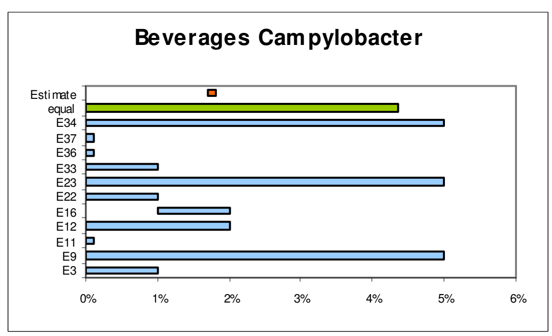

Chicken Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Eggs Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
2%
4%
6%
8%
10%


Dairy Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
10%
20%
30%
40%
50%
60%


Fish Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
5%
10%
15%
20%
25%
30%
35%
40%


Fruit and Vegetables Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
5%
10%
15%
20%
25%
30%
35%
40%


Beverages Campylobacter
Estimate
equal
E34
E37
E36
E33
E23
E22
E16
E12
E11
E9
E3
0%
1%
2%
3%
4%
5%
6%

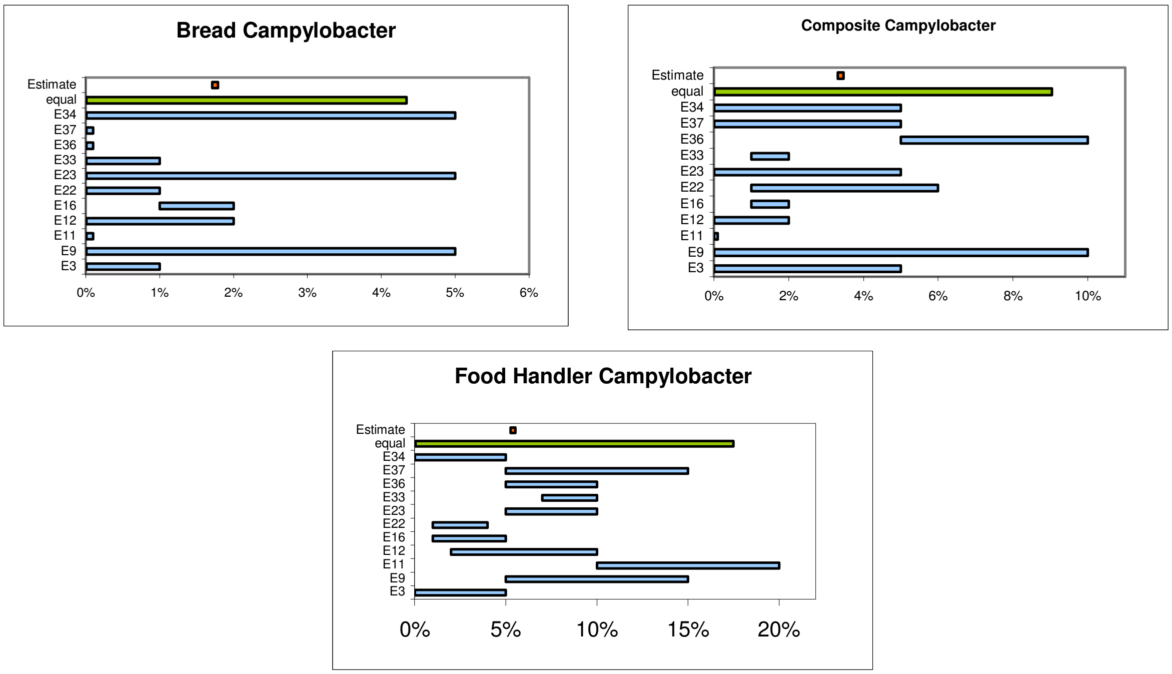


Figure 13

These sets of graphs show how broad the interval for the equal weight Decision Maker can be as a result of the differences among the experts' assessments. After observing these plots, the next step was to run the Probabilistic Inversion fitting not only the 5% and 95% quantile, but also the 50% quantile of the distribution. In this way, there is extra information extracted from the experts' opinions and the specification of the decision maker distribution is more complete. Notice that adding an extra quantile is equivalent to introducing an extra constraint. Naturally, finding the weights that fit the given quantiles could be harder and therefore it is possible that a problem that is feasible fitting two quantiles, is not while fitting three quantiles.

Even though, the estimates changed after including an extra quantile, the differences were not drastic. The changes between the two sets of results are bigger for the pathways than for the food categories. This is partially due to the less number of items in each case. When there are fewer items, the results are more sensitive to the changes included. The results adding the 50% quantile are summarized in Appendix A. These results are presented in a table similar to the tables including the results fitting only the 5% and 95% quantile. For an explanation of the data presented in this tables see the beginning of this chapter.

Since the current application enables to discard contamination of certain pathogens through specific pathways or food categories, a trial exercise was done using these statements as seed variables. The summary of the items used as seed variables are included in Table 9 and Table 10. The realization or actual value for these items is equal to 0, meaning that contamination through that route does not take place or is very rare and therefore can be neglected.

PATHWAYS	
PATHOGENS	ROUTE
Listeria Monocytogenes	Contact with sick person
Bacillus Cereus Toxin	Environment Contact with sick person Animal contact
Clostridium Perfringens Toxin	Environment Contact with sick person Animal contact
Staphylococus Aureus Toxin	Environment Contact with sick person Animal contact
Enterovirus	Animal contact
Hepatitis A Virus	Animal contact
Hepatitis E Virus	Animal contact
Rotavirus	Animal contact
Norovirus	Animal contact
Toxoplasma	Contact with sick person Animal contact

Table 9

FODD CATEGORIES	
PATHOGENS	ROUTE
Campylobacter	Eggs Bread, grains, pastas and bakery products
STEC O 157	Eggs
Listeria Monocytogenes	Eggs
Bacillus Cereus Toxin	Eggs Beverages Bread, grains, pastas and bakery products Food Handlers
Clostridium Perfringens Toxin	Eggs Beverages Bread, grains, pastas and bakery products Food Handlers
Staphylococus Aureus Toxin	Eggs Beverages Bread, grains, pastas and bakery products

	Food Handlers
Enterovirus	Beef and Lamb Pork Chicken and other poultry Eggs Dairy products Bread, grains, pastas and bakery products
Hepatitis A Virus	Beef and Lamb Pork Chicken and other poultry Eggs Dairy products Bread, grains, pastas and bakery products
Hepatitis E Virus	Beef and Lamb Chicken and other poultry Eggs Dairy products Bread, grains, pastas and bakery products
Rotavirus	Beef and Lamb Pork Chicken and other poultry Eggs Dairy products Bread, grains, pastas and bakery products
Norovirus	Beef and Lamb Bread, grains, pastas and bakery products
Cryptosporidium Parvum	Eggs
Giardia lamblia	Eggs
Toxoplasma	Chicken and other poultry Eggs Dairy Beverages Bread, grains, pastas and bakery products Food Handlers

Table 10

Even though these were the items defined, not all were taken as seed variables. In some cases, the experts had already defined as equal to zero. In other cases the quantiles resulting from the Decision Maker distribution including all seed variables introduced too many constraints and it was not possible to fit the quantiles.

The detailed results including the 50% quantile and the seed variables are presented in Appendix A as well with a note of the seed variables used in each case.

CHAPTER 7: PAIRED COMPARISONS

Paired comparison is used in decision theory to determine the relative importance of items. The objective is to reach a consensus among members of a group of experts and estimate the value for each alternative. The idea is to establish a ranking of items that represent the perception and knowledge of the group in a rational way in order to make decisions. This is done by asking experts to compare each option with each other one-by-one. In each comparison, the expert has to determine which of the two is more important, more likely to happened or preferred, depending on the application.

It is possible to calculate a score of all the items based on the rankings resulting from the experts' assessments. Let's examine the method through an example. Assume that the aim is to know the relative probabilities of the following pathways for Salmonella contamination: food ingestion, environment, direct animal contact, contact with a sick person and contamination abroad (meaning that contamination occurred by any pathway outside the Netherlands). Note that the method includes the assumption that the pathways are Collectively Exhaustive and Mutually Exclusive i.e. these five options are the only possible pathways to get Salmonella and a person is contaminated by either one of the pathways but not by more than one simultaneously.

Suppose that we are going to determine the probabilities with the help of experts. Each of them will have to order the possible pathways, from the most probable to the least probable. The analyst will ask experts independently about his or her preferences by asking the expert to compare pairs of options, which makes the process easier.

For each pair of items an expert can say either that one is preferred over the other, that both are equally preferred or have no assessment regarding that pair at all. This elicitation method allows experts to skip questions if they are not able to determine a preference between a pair. In that case, the data is said to have *void comparisons*. (Cooke 1981).

The information given by each expert can be summarized in a matrix like the one presented in Figure 14. Take i as the row and j as the column of a matrix. Then, the ij element of the matrix symbolizes the relation between item i and item j. If element i is preferred over j, then there is a one in position ij. There is a zero otherwise. For example, this expert thinks that is more likely to get salmonella by eating contaminated food than through direct animal contact. And he/she thinks that is more probable to get infected by contact with a sick person than by environment. Note that the diagonal is not defined and once an expert chooses a preference between item i and j, both elements of the matrix, ij and ji are filled. It is also possible for an expert to say that there is no preference between the two items. In that case a number 2 will appear in the matrix.

	FOOD	ENVIRON-MENT	SICK PERSON	ANIMAL CONTACT	ABROAD
FOOD		1	0	1	1
ENVIRON-MENT	0		0	1	1
SICK PERSON	1	1		1	1
ANIMAL CONTACT	0	0	0		0
ABROAD	0	0	0	1	

Figure 14

Additionally, from the data itself, the analyst is interested in knowing the quality of the assessments of each expert. Usually some individuals have inconsistencies in their preferences. For instance, let a, b and c be the elements of the set of items under consideration. If a given experts states the following preferences simultaneously, there is an incongruence: item *a* is preferred over item *b* (*a* > *b*), item *c* is prefers over *a* (*c* > *a*) and item *b* is preferred over *c* (*b* > *c*). In a situation like this, the three items are called *circular triads.* It is common to have some circular triads in the experts' assessments. However, a large number of circular triads can be an indicator that the expert is having trouble defining his preferences.

Additionally, the Coefficient of Agreement u can be used to estimate the probability that the experts agreement is due to randomness. The maximum value of the Coefficient of Agreement is one, and it will occur when there is complete agreement. The fact that all experts agree is independent of the existence of circular triads.

Consider the assessments of n experts. Let $a(ij)$ be the number of times an expert prefers item *i* over item *j*, then $a(ji) = n - a(ij)$. When there is absolute consensus among all experts, half of the $a(ij)$ are equal to 0, while the other half are equal to n.

Define $S = \sum_{i \neq j} \binom{a(ij)}{2}$. The Coefficient of Agreement u is defined as follows.

$$u = \frac{2S}{\binom{n}{2}\binom{t}{2}} - 1$$

Where n is the number of experts and t is the number of items. It is possible to test the hypothesis that all agreements are due to randomness using the Coefficient of Agreement.

Besides, it is also possible to define the Coefficient of Concordance W, which in complete agreement would be equal to 1 as well. Let $R(i,e)$ be the rank of item i according to the answers of expert e. Then the sum of the ranks $R(i)$ is defined as follows.

$$R(i) = \sum_e R(i,e)$$

The Coefficient of Concordance may be used in hypothesis testing to check if the preferences were giving randomly.

Additionally, it is possible to determine a ranking and the conditional probability that item i is preferred over j given that only i and j were possible and the probability of choosing i over all other options

When considering N items, (in this example, 5 pathways), each expert has to make $\binom{N}{2}$ comparisons. This represents more effort and time, than actually asking the experts to rank the N items directly. The advantage of asking experts to compare the items pair wise is that this method allows the analyst to identify inconsistencies in the experts' beliefs. Besides, comparing pairs is actually the logic that any individual follows while building a ranking, so the method is not altering the results. In this way, the analyst is not altering the experts' natural way of building a ranking while studying the experts' performance.

Bradley and Terry

Notice that right after pair comparisons the result is a ranking that says nothing about the internal value of each option, or the difference in value (probability, money, utility, time) between given two options.

This method calculates the intrinsic value of each of the items compared by the experts. The values corresponding to each item are calculated using the probability that I is preferred over j by assuming that this probability is equal to the value of the preferred item over the sum of the two values.

$$P(ij) = \frac{V(i)}{V(i) + V(j)}$$

The calculated values $V(i)$ have an interesting property; the sum over al items is equal to 1. This property is very convenient for the present application since the aim of the experiment is to calculate probabilities that sum up to 1. Then since experts are actually saying which item is more likely to happened, the actual values will be numbers between 1 and 1 and the sum of the values is equal to 1, the Bradley and Terry results could be interpreted as an estimate for the desired probabilities.

The disadvantage of this method to estimate probabilities is the lack of accuracy. In fact the situation is a trade off. The paired comparisons elicitation does not demand as much knowledge and effort as other methods such as the classical model which asks for quantiles. Even though the number of comparisons is very large, the elicitation process is not as heavy for the experts and allows them to answer faster.

Application in the present Project

In the initial proposal the method chosen to be applied was paired comparisons and the Bradley and Terry model. After having the paired comparisons results using Bradley and Terry method, the result is a score for each of the items (in this example pathways and food categories respectively), that sum to one. These scores are the “best estimates” for the fractions or probabilities using this method.

However there are some difficulties using this method in this application. The method is not conceived to be estimate probabilities but scores that assign a value to each of the items in a scale. Then the estimate of the probability would not be as accurate as the classical method.

The scores of each of the items are proportional to the number of experts that prefer each item over other. For example, if there is an a particular item that is preferred over the whole set of items by all experts, then the score for this particular item is going to be very close to 1. This is not desirable in the present application because the fact that all experts agree that a particular transmission pathway is more likely to happen that any other, does not mean that its corresponding probability is equal or close to 1.

CHAPTER 8: EXPERIMENT WITH PAIRED COMPARISONS

The Elicitation (paired comparisons)

As stated before, the present analysis includes 17 pathogens and two groups of items: the pathways and food groups of 5 and 11 categories respectively. The number of comparison for N items is equal to $\binom{N}{2}$. This means, that an expert has to answer $\binom{5}{2}+\binom{11}{2}$ which is 65 comparisons per pathogen. If an expert is able to answer the elicitation for all pathogens, then this expert is agreeing to answer 1105 comparisons. This is off course a very large number, but bear in mind that these are only comparisons. However, filling in an elicitation this long will take some time.

Ideally, elicitation should be completed by experts in the presence of the analyst in case there is any misunderstanding or doubt regarding to the questionnaire. However, it was not possible to ask experts to fill the whole elicitation on one day and because of the experts' multiple occupations it was not feasible to meet several times to do this exercise. The alternative was to design a webpage where experts could log on and off and fill in the comparisons according to their time constraints. Ir. Rabin Neslo designed the website to gather the data and manage the data bases of the information collected. In order to let experts become familiar with the webpage, the method and the study itself, a meeting was arranged. The experts who were able to attend were asked to fill the questionnaire for Salmonella. Additionally, they had the opportunity to see the results of the model according to their answers.

Fifty seven experts were invited to participate in the foodborne attribution project. Thirty seven agreed to participate and twenty two accepted the invitation to attend to the introductory exercise. On November 14, 2006, eleven experts decided to attend to the meeting where they filled in both questionnaires for food categories and pathways for Salmonella. Experts were together in a room and they could ask questions about the website and any of the defined categories or pathways. Appendix C includes an example of the appearance and format of the website.

In the pathways elicitation, three experts presented one circular triads while one presented two circular triads. The p-value for the null hypothesis that the preferences are given randomly are equal to 0.224 for the expert with two circular triads and 0.117 for the experts that had one circular triad. These two values lead the annalist to conclude that there is not enough information to reject the null hypothesis, meaning that there is no information to actually say that the assessments of these experts were *not* done randomly.

Item name	Score	Conf L.	Conf U.
Food Ingestion	0.9557	0.8335	0.9978
Environment	0.0123	0.0003	0.0528
Contact with sick person	0.0015	0.0000	0.0054
Direct animal contact	0.0046	0.0001	0.0145
Contamination abroad	0.0259	0.0010	0.1058

Table 11 Bradley and Terry results for pathways

Item name	Score	Conf L.	Conf U.
Beef and lamb	0.0524	0.0189	0.1079
Pork	0.1601	0.0632	0.2745
Chicken and poultry	0.2909	0.1619	0.4658
Eggs	0.4492	0.2756	0.6481
Dairy products	0.0098	0.0016	0.0211
Fish and shellfish	0.0069	0.0012	0.0163
Fruit and vegetables	0.0061	0.0013	0.0148
Beverages	0.0012	0.0001	0.0029
Bread, grains and pasta	0.0023	0.0003	0.0049
Composite Foods	0.0118	0.0026	0.0251
Food infected by Humans or Animals	0.0093	0.0015	0.0195

Table 12 Bradley and Terry results for food categories

As the group of experts studied the Bradley and Terry results based on their own assessments, the weaknesses of the model were exposed and the idea of looking for an alternative method emerged. The resulting estimates for the probabilities are included in Table 11 and Table 12.

After filtering the experts with high p-values (i.e. p-values greater than 0.05) the results of the Bradley and Terry Method changed to the values in Table 13. This situation only took place for the pathways' elicitation.

Item name	Score	Conf L.	Conf U.
Food Ingestion	0.9977	0.9973	0.9978
Environment	0.0008	0.0003	0.0015
Contact with sick person	0.0000	0.0000	0.0001
Direct animal contact	0.0003	0.0000	0.0006
Contamination abroad	0.0011	0.0006	0.0021

Table 13 Bradley and Terry results for pathways filtering experts

The experts found that the values were not very accurate, not credible. For this specific pathogen, experts were expecting within the pathways, that the probability of contamination through food ingestion was high with respect to all others. However the resulting value was higher than expected while the rest of the probabilities were almost equal to zero, which was considered as inaccurate. There was less criticism against the results in the food categories case. Nevertheless, the results were not satisfactory and this type of elicitation was discarded.

As said before, the study includes seventeen pathogens, five pathways and eleven food categories; the number of comparisons is very big. Naturally, is no feasible to complete the elicitation on one day. Therefore, the elicitation was done using a webpage where experts could log on and for their convenience with an introductory meeting. In this meeting experts had a brief explanation of the method and the opportunity to interact with the webpage and ask some questions. The result of this assembly was the completion of the questionnaire for Salmonella.

However the paired comparison method was not ideal for this situation. Then information gathered in the original exercise for Salmonella as a trial to experiment and compare with the other information that we gathered later on.

The present chapter includes a comparison between the results of the paired comparisons model and the probabilistic inversion results. The motivation of this exercise is experimental. It would be very interesting to see how different the results with the two methods are, while the recollection of the data is more demanding for one of them.

From the 11 experts that participated in the paired comparisons elicitation, 7 also completed the e-mail elicitation for Probabilistic Inversion, 2 experts agreed to participate and retired for lack of time and 2 experts never replied to the invitation.

In order to compare both methods, Probabilistic Inversion and Paired Comparison, the results of both models filtering the experts who did not participate in both of the questionnaires are presented below. The reason why not all experts' assessments are includes is because the objective is to see how both methods behave compared with one another. Therefore the information in which both results are based should be the same.

As a result, the experts who were included in this experimental exercise are experts 9, 12, 22, 33, 36 and 37. The results using probabilistic inversion over the quantiles given by this set of experts using two quantiles (5% and 95% quantile) are given in Table 14 and Table 15.

Salmonella					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	**58.40%**	3.12E-01	9.38E-01	3.12E-01	8.85E-01
Environment	**15.10%**	2.64E-04	2.91E-01	1.48E-04	2.91E-01
Contact with sick person	**5.27%**	5.31E-05	8.62E-02	5.79E-05	9.28E-02
Direct animal contact	**7.63%**	2.66E-04	1.43E-01	2.62E-04	1.43E-01
Contamination abroad	**13.60%**	2.56E-02	2.39E-01	2.60E-02	2.39E-01
	Number of experts	6		Entropy	7.32E+00
	Participating experts			Method	IPF

Table 14. Estimates for the trial exercise - Pathways

Salmonella					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	**13.40%**	5.17E-02	2.72E-01	5.19E-02	2.63E-01
Pork	**14.70%**	5.98E-02	4.97E-01	3.37E-02	4.44E-01
Chicken and poultry	**14.40%**	7.18E-02	4.60E-01	4.75E-02	4.66E-01
Eggs	**21.30%**	1.35E-01	5.51E-01	1.35E-01	4.89E-01
Dairy products	**5.47%**	2.43E-04	1.88E-01	2.63E-04	1.88E-01
Fish and shellfish	**3.74%**	1.06E-04	7.98E-02	1.76E-04	8.28E-02
Fruit and vegetables	**6.97%**	1.85E-04	2.19E-01	2.47E-04	2.18E-01
Beverages	**2.20%**	1.00E-04	4.37E-02	4.26E-04	4.45E-02
Bread, grains and pasta	**3.45%**	1.09E-04	8.12E-02	6.81E-05	8.05E-02
Composite Foods	**6.83%**	6.63E-04	1.83E-01	2.86E-04	1.82E-01
Food infected by Humans or Animals	**7.54%**	1.49E-02	1.79E-01	1.47E-02	1.82E-01
	Number of experts	7		Entropy	5.52E+00
	Participating experts			Method	IPF

Table 15. Estimates for the trial exercise – Food Categories

The values are significantly different. The only similarity is the relative importance. Both methods agree in the items that have bigger relative fraction. However, in the case of Paired Comparisons the gap between the items with high probabilities and the ones with low probabilities is too big. The participating experts agreed that these results do not resemble the actual reality and therefore the modeled is not appropriate to estimate the fractions under the study.

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

The present study examined the two alternatives in order to estimate the fraction of transmission route for a set of seventeen pathogens. The routes were classified in pathways and within food ingestion there were eleven sub categories. The two alternatives were based on experts' elicitation. The first method considered was Paired Comparisons. Although the method is very convenient because of the simplicity in the recollection of the data, allowing experts to complete the elicitations in less time, the results were not satisfactory for this application.

The second method consisted was to apply Probabilistic Inversion over the quantiles of the Decision Maker distribution, which is based on the quantiles given by the experts through an elicitation. The present report includes three sets of results. The first one, is the set of results fitting the 5% and 95% quantile. The second set additionally fits the 50% quantile. Finally, the last set is based on the quantiles using some of the items as seed variables.

Even though the objective of the project was to estimate the probabilities of contamination the simplest way, the omission of seed variables is not recommended. It is definitely important to have a criterion to actually measure the performance of the experts participating. Furthermore, in the scenario where there are no seed variables and the Decision Maker is built using equal weight for each expert, the results could be meaningless and misleading. In that case, having a big group of experts can be a disadvantage. When experts disagree and all of them have the same weight, the Decision Maker distribution becomes too broad and not very informative.

In general, the superiority among the methods is clear. The most reliable results are obtained when including seed variables. In an elicitation without seed variables, there is no way to test the expertise of the individuals participating in the study. Even though it is possible to identify that an expert is an outlier, this type of elicitation does not allow the analyst to quantify the expert assessment's accuracy quantitatively.

Specifically, for the present application it is difficult to determine an absolute and general preference over all pathogens considered. However, there is a general satisfaction with the resulting values as the numbers do not significantly differ among the three methods and constitute a solid starting point of estimation of the desired fractions for policy making.

APPENDIX A: RESULTS

PATHWAYS

The results of Probabilistic Inversion and the estimates after re-sampling using 5% and 50% quantile are presented in this section. The values in the columns named DM correspond to the quantiles of the Decision Maker distribution which the distribution built giving equal weight to all experts. The values in the columns under the name Re-Sampling are the corresponding quantiles after sampling using the weights calculated with Probabilistic Inversion. Ideally the two set of columns should be the same. Finally the percentages in the column called Estimate Fraction are the mean values after re-sampling. These values are the final result and represent the probability of contamination for the corresponding pathway.

Campylobacter spp.					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	42.10%	2.27E-01	8.52E-01	1.58E-01	8.37E-01
Environment	20.60%	3.41E-04	7.31E-01	3.29E-04	7.31E-01
Contact with sick person	6.28%	1.45E-04	1.23E-01	3.62E-04	1.23E-01
Direct animal contact	19.10%	2.25E-03	5.98E-01	2.21E-03	5.98E-01
Contamination abroad	12.00%	2.00E-03	2.84E-01	2.18E-03	2.88E-01
	Number of experts	12		Entropy	9.02E+00
	Participating experts			Method	IPF

STEC O157					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	40.40%	2.13E-01	8.35E-01	1.51E-01	8.29E-01
Environment	17.20%	3.34E-04	4.66E-01	3.51E-04	4.66E-01
Contact with sick person	10.20%	3.29E-04	2.26E-01	3.79E-04	2.26E-01
Direct animal contact	20.50%	1.15E-03	7.61E-01	1.28E-03	7.62E-01
Contamination abroad	11.70%	2.63E-04	2.67E-01	2.57E-04	2.67E-01
	Number of experts	7		Entropy	9.30E+00
	Participating experts			Method	IPF

Non-O157 STEC					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	42.60%	2.08E-01	7.83E-01	2.09E-01	7.75E-01
Environment	14.50%	1.35E-04	2.93E-01	1.06E-04	2.93E-01
Contact with sick person	9.74%	2.87E-04	1.96E-01	2.87E-04	1.97E-01
Direct animal contact	27.60%	1.07E-01	4.82E-01	1.08E-01	4.82E-01
Contamination abroad	5.60%	1.00E-04	9.81E-02	2.57E-04	1.02E-01
	Number of experts	3		Entropy	8.32E+00
	Participating experts			Method	IPF

Listeria Monocytogenes					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	69.30%	4.68E-01	9.90E-01	4.68E-01	9.84E-01
Environment	6.73%	1.70E-04	1.80E-01	1.79E-04	1.80E-01
Contact with sick person	5.25%	1.59E-04	1.32E-01	1.56E-04	1.32E-01
Direct animal contact	5.35%	2.45E-04	1.34E-01	2.26E-04	1.33E-01
Contamination abroad	13.40%	1.14E-04	3.99E-01	1.13E-04	3.99E-01
	Number of experts	7		Entropy	5.76E-08
	Participating experts			Method	IPF

Mycobacterium avium					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	41.80%	5.06E-04	7.84E-01	4.88E-04	7.91E-01
Environment	19.00%	1.75E-04	5.78E-01	1.22E-04	5.76E-01
Contact with sick person	18.30%	2.99E-04	5.60E-01	1.96E-04	5.73E-01
Direct animal contact	8.73%	1.72E-04	2.71E-01	1.75E-04	2.72E-01
Contamination abroad	12.20%	3.44E-04	3.67E-01	3.47E-04	3.87E-01
	Number of experts	4		Entropy	1.00E+01
	Participating experts			Method	

Salmonella spp					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	54.60%	3.32E-01	9.33E-01	3.24E-01	8.83E-01
Environment	12.90%	1.70E-04	2.86E-01	1.49E-04	2.87E-01
Contact with sick person	9.27%	7.36E-05	1.79E-01	3.12E-04	1.89E-01
Direct animal contact	9.23%	3.93E-04	1.81E-01	3.69E-04	1.85E-01
Contamination abroad	14.10%	2.75E-02	2.56E-01	2.78E-02	2.61E-01
	Number of experts	8		Entropy	8.20E+00
	Participating experts			Method	IPF

Bacillus cereus toxin					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	89.30%	8.09E-01	9.98E-01	6.75E-02	9.98E-01
Environment	1.10%	1.00E-04	4.06E-02	6.49E-05	4.05E-02
Contact with sick person	1.15%	1.00E-04	3.95E-02	9.34E-05	3.99E-02
Direct animal contact	1.12%	1.00E-04	3.95E-02	1.02E-04	4.07E-02
Contamination abroad	7.27%	1.45E-04	9.12E-01	1.35E-04	9.14E-01
	Number of experts	4		Entropy	7.62E+00
	Participating experts			Method	IPF

Clostridium perfringens toxin					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	90.40%	7.23E-01	9.96E-01	7.15E-01	9.96E-01
Environment	2.19%	1.13E-04	4.50E-02	1.14E-04	5.04E-02
Contact with sick person	2.08%	1.13E-04	4.50E-02	1.16E-04	4.66E-02
Direct animal contact	2.09%	1.13E-04	4.50E-02	1.13E-04	4.88E-02
Contamination abroad	3.24%	1.31E-04	9.28E-02	1.22E-04	9.27E-02
	Number of experts	4		Entropy	7.76E+00
	Participating experts			Method	IPF

Staphylococcus aureus toxin					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	87.30%	7.27E-01	9.99E-01	7.28E-01	9.99E-01
Environment	3.60%	1.08E-04	9.33E-02	1.22E-04	9.31E-02
Contact with sick person	3.23%	1.00E-04	8.33E-02	9.72E-05	8.43E-02
Direct animal contact	2.15%	1.00E-04	4.71E-02	1.01E-04	4.71E-02
Contamination abroad	3.76%	1.11E-04	9.85E-02	1.04E-04	9.79E-02
	Number of experts	4		Entropy	7.97E+00
	Participating experts			Method	IPF

Enterovirus					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	6.26%	1.00E-04	9.64E-02	7.41E-04	1.62E-01
Environment	24.60%	1.68E-04	4.91E-01	1.53E-04	6.00E-01
Contact with sick person	60.10%	3.08E-01	9.27E-01	3.02E-01	9.15E-01
Direct animal contact	2.18%	1.00E-04	1.88E-02	9.05E-05	1.88E-02
Contamination abroad	6.81%	1.75E-04	1.48E-01	1.67E-04	1.47E-01
	Number of experts	2		Entropy	5.36E+00
	Participating experts			Method	IPF

Hepatitis A virus					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	11.40%	5.00E-02	2.00E-01	5.00E-02	2.00E-01
Environment	11.10%	5.00E-02	1.92E-01	5.01E-02	1.92E-01
Contact with sick person	18.20%	5.21E-02	8.95E-01	5.25E-02	4.16E-01
Direct animal contact	0%	0	0	0	0
Contamination abroad	59.30%	5.10E-01	8.00E-01	7.63E-02	7.97E-01
	Number of experts	2		Entropy	7.93E+00
	Participating experts			Method	PARFUM

Hepatitis E virus					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	13.80%	1.00E-04	3.82E-01	9.95E-05	3.82E-01
Environment	24.90%	1.91E-04	9.45E-01	1.91E-04	7.48E-01
Contact with sick person	7.55%	1.00E-04	1.91E-01	1.00E-04	1.97E-01
Direct animal contact	10.80%	1.00E-04	2.85E-01	9.43E-05	2.85E-01
Contamination abroad	42.90%	2.09E-01	6.83E-01	2.09E-01	6.84E-01
	Number of experts	2		Entropy	9.50E+00
	Participating experts			Method	IPF

Norovirus					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	16.70%	1.67E-02	5.34E-01	1.63E-02	4.71E-01
Environment	14.20%	5.03E-04	4.35E-01	4.76E-04	4.26E-01
Contact with sick person	55.50%	4.19E-01	8.87E-01	4.19E-01	8.77E-01
Direct animal contact	4.95%	1.00E-04	9.64E-02	8.55E-05	9.63E-02
Contamination abroad	8.70%	3.71E-04	1.98E-01	7.27E-04	1.98E-01
	Number of experts	5		Entropy	7.93E+00
	Participating experts			Method	IPF

Rotavirus					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	13.00%	1.34E-02	2.84E-01	1.33E-02	2.84E-01
Environment	17.00%	2.51E-04	4.62E-01	9.08E-04	4.59E-01
Contact with sick person	58.10%	4.28E-01	8.94E-01	4.28E-01	8.99E-01
Direct animal contact	3.03%	1.00E-04	5.00E-02	8.89E-05	5.00E-02
Contamination abroad	8.86%	1.65E-04	1.94E-01	5.71E-04	1.92E-01
	Number of experts	3		Entropy	7.29E+00
	Participating experts			Method	IPF

Cryptosporidium parvum					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	11.90%	1.75E-04	1.95E-01	2.66E-04	1.96E-01
Environment	27.70%	1.00E-01	3.84E-01	1.01E-01	3.86E-01
Contact with sick person	27.40%	1.00E-01	3.84E-01	1.00E-01	3.84E-01
Direct animal contact	13.40%	5.00E-02	1.92E-01	5.04E-02	1.92E-01
Contamination abroad	19.60%	4.50E-02	2.89E-01	4.51E-02	2.89E-01
	Number of experts	2		Entropy	8.63E+00
	Participating experts			Method	IPF

Giardia lamblia					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	13.00%	1.36E-04	2.40E-01	2.63E-04	2.40E-01
Environment	23.90%	1.03E-01	3.74E-01	1.03E-01	3.74E-01
Contact with sick person	34.70%	1.07E-01	5.63E-01	1.08E-01	5.64E-01
Direct animal contact	10.70%	3.12E-04	1.98E-01	2.68E-04	1.98E-01
Contamination abroad	17.70%	5.34E-02	2.82E-01	5.20E-02	2.89E-01
	Number of experts	3		Entropy	9.20E+00
	Participating experts			Method	IPF

Toxoplasma gondii					
Pathways	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Food Ingestion	55.80%	3.24E-01	8.92E-01	2.63E-01	8.82E-01
Environment	36.20%	5.58E-02	6.61E-01	5.97E-02	6.64E-01
Contact with sick person	0.87%	1.00E-04	8.86E-03	1.32E-04	8.66E-03
Direct animal contact	2.52%	1.00E-04	2.64E-02	1.92E-04	2.64E-02
Contamination abroad	4.62%	2.79E-04	9.95E-02	1.90E-03	9.41E-02
	Number of experts	3		Entropy	3.81E+00
	Participating experts			Method	IPF

FOOD CATEGORIES

Similarly to the previous set of tables, the results fitting the 5% and 95% quantile for the Food Categories are included in this section. The values in the columns named DM correspond to the quantiles of the Decision Maker distribution which is the distribution built giving equal weight to all participating experts. The values in the columns under the name Re-Sampling are the corresponding quantiles after sampling using the weights calculated with Probabilistic Inversion. Ideally the two set of columns should be equal to each other. Finally the percentages in the column called Estimate Fraction are the mean values after re-sampling. These values are the final result and represent the probability of contamination for the ingestion of the corresponding food category.

Campylobacter spp.					
Food Categories	Estimate Fraction	DM		Re-Weighted Sample	
		5%	**95%**	**5%**	**95%**
Beef and lamb	4.12%	2.20E-04	1.64E-01	2.43.E-04	1.65.E-01
Pork	5.08%	3.06E-04	1.84E-01	3.11.E-04	1.85.E-01
Chicken and poultry	53.90%	1.72E-01	8.67E-01	1.71.E-01	8.62.E-01
Eggs	3.05%	1.11E-04	9.45E-02	9.36.E-05	1.00.E-01
Dairy products	8.92%	5.27E-04	4.50E-01	5.56.E-04	4.40.E-01
Fish and shellfish	6.96%	3.33E-04	2.71E-01	2.40.E-04	2.74.E-01
Fruit and vegetables	5.31%	2.10E-04	2.28E-01	2.11.E-04	2.47.E-01
Beverages	1.71%	1.03E-04	4.34E-02	1.06.E-04	4.22.E-02
Bread, grains and pasta	2.33%	1.06E-04	6.46E-02	1.04.E-04	6.19.E-02
Composite Foods	3.31%	1.33E-04	9.04E-02	1.34.E-04	9.61.E-02
Food infected by Humans or Animals	5.27%	5.55E-04	1.75E-01	5.57.E-04	1.75.E-01
	Number of experts	11		Entropy	5.34E+00
				Method	IPF

STEC 0157.					
Food Categories	Estimate Fraction	DM		Re-Weighted Sample	
		5%	**95%**	**5%**	**95%**
Beef and lamb	44.10%	1.59E-01	8.75E-01	1.59E-01	8.78E-01
Pork	6.36%	1.34E-04	2.50E-01	1.20E-04	2.49E-01
Chicken and poultry	3.06%	1.13E-04	9.51E-02	9.79E-05	9.44E-02
Eggs	2.11%	1.00E-04	4.51E-02	9.47E-05	4.86E-02
Dairy products	7.40%	4.00E-04	2.80E-01	3.72E-04	2.81E-01
Fish and shellfish	2.90%	1.00E-04	7.85E-02	1.02E-04	7.79E-02
Fruit and vegetables	7.06%	4.00E-04	2.88E-01	3.65E-04	2.90E-01
Beverages	3.57%	1.18E-04	1.25E-01	1.19E-04	1.24E-01
Bread, grains and pasta	2.93%	1.03E-04	8.53E-02	9.88E-05	8.47E-02
Composite Foods	3.55%	1.14E-04	1.13E-01	1.19E-04	1.16E-01
Food infected by Humans or Animals	16.90%	3.94E-04	8.73E-01	4.05E-04	7.10E-01
	Number of experts	7		Entropy	7.12E+00
				Method	IPF

Non-O157 STEC					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	61.70%	3.04E-01	7.82E-01	2.67E-01	7.93E-01
Pork	8.71%	1.32E-04	1.93E-01	4.84E-04	1.90E-01
Chicken and poultry	2.80%	1.30E-04	9.70E-02	1.41E-04	8.86E-02
Eggs	1.14%	1.00E-04	4.40E-02	5.94E-05	4.28E-02
Dairy products	4.64%	1.35E-04	2.44E-01	1.26E-04	2.52E-01
Fish and shellfish	2.51%	1.00E-04	5.00E-02	1.06E-04	4.90E-02
Fruit and vegetables	4.39%	2.87E-04	1.99E-01	1.27E-04	1.86E-01
Beverages	3.81%	1.14E-04	1.41E-01	4.74E-05	1.33E-01
Bread, grains and pasta	2.23%	1.00E-04	8.78E-02	1.05E-04	8.70E-02
Composite Foods	2.19%	1.00E-04	9.06E-02	9.58E-05	8.59E-02
Food infected by Humans or Animals	5.85%	2.83E-04	1.94E-01	3.23E-04	2.22E-01
	Number of experts	3		Entropy	3.45E+00
	Participating experts			Method	PARFUM

Listeria Monocytogenes					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	11.20%	5.11E-02	2.49E-01	5.11E-02	2.94E-01
Pork	9.34%	1.74E-03	5.52E-01	1.69E-03	2.58E-01
Chicken and poultry	6.61%	1.88E-04	1.71E-01	1.57E-04	1.70E-01
Eggs	3.82%	1.08E-04	9.02E-02	2.98E-05	1.18E-01
Dairy products	24.70%	1.40E-01	6.88E-01	1.41E-01	4.95E-01
Fish and shellfish	17.80%	1.05E-01	4.34E-01	1.05E-01	4.61E-01
Fruit and vegetables	7.58%	1.83E-04	2.50E-01	2.00E-04	2.48E-01
Beverages	2.55%	1.03E-04	4.09E-02	8.95E-05	6.86E-02
Bread, grains and pasta	5.90%	1.21E-04	1.59E-01	6.94E-05	1.64E-01
Composite Foods	5.59%	4.25E-04	1.92E-01	3.48E-04	1.90E-01
Food infected by Humans or Animals	4.87%	1.12E-04	8.81E-02	8.70E-05	8.99E-02
	Number of experts	9		Entropy	5.20E+00
	Participating experts			Method	IPF

Mycobacterium avium					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	6.01%	1.61E-04	4.56E-01	1.52E-04	4.54E-01
Pork	41.10%	1.54E-04	8.53E-01	9.44E-05	8.57E-01
Chicken and poultry	5.60%	1.00E-04	4.71E-02	1.48E-04	6.85E-02
Eggs	2.38%	1.00E-04	8.37E-03	6.38E-04	6.38E-04
Dairy products	5.34%	1.29E-04	1.96E-01	2.68E-02	2.68E-02
Fish and shellfish	6.80%	1.00E-04	8.60E-02	1.16E-04	1.54E-01
Fruit and vegetables	2.33%	1.00E-04	8.92E-02	6.12E-05	9.21E-02
Beverages	5.12%	1.00E-04	8.33E-02	6.00E-05	8.21E-02
Bread, grains and pasta	1.40%	1.00E-04	8.37E-03	1.10E-04	7.64E-03
Composite Foods	3.59%	1.17E-04	1.38E-01	3.67E-05	1.49E-01
Food infected by Humans or Animals	20.30%	1.59E-04	3.48E-01	1.26E-04	3.46E-01
	Number of experts	4		Entropy	3.11E+00
	Participating experts			Method	IPF

Salmonella spp					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	12.60%	5.22E-02	2.84E-01	5.22E-02	2.84E-01
Pork	14.30%	6.47E-02	4.73E-01	6.48E-02	3.62E-01
Chicken and poultry	14.80%	7.78E-02	4.50E-01	4.75E-02	4.66E-01
Eggs	22.20%	1.50E-01	5.43E-01	1.05E-01	5.44E-01
Dairy products	6.54%	2.51E-04	2.47E-01	2.62E-04	2.49E-01
Fish and shellfish	4.09%	1.18E-04	9.61E-02	1.43E-04	9.89E-02
Fruit and vegetables	6.33%	2.74E-04	2.04E-01	2.68E-04	2.03E-01
Beverages	3.14%	1.04E-04	8.46E-02	7.62E-05	8.50E-02
Bread, grains and pasta	4.26%	1.11E-04	1.21E-01	9.61E-05	1.21E-01
Composite Foods	6.01%	4.77E-04	1.78E-01	4.38E-04	1.76E-01
Food infected by Humans or Animals	5.71%	1.43E-03	1.77E-01	1.29E-03	1.77E-01
	Number of experts	10		Entropy	5.93E+00
	Participating experts			Method	IPF

Bacillus cereus toxin					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	7.17%	1.45E-04	1.80E-01	3.68E-02	3.68E-02
Pork	3.45%	1.44E-04	1.77E-01	1.75E-04	1.83E-01
Chicken and poultry	1.63%	1.21E-04	9.67E-02	3.21E-03	3.21E-03
Eggs	3.63%	1.20E-04	1.82E-01	4.16E-06	1.52E-01
Dairy products	5.76%	1.39E-04	2.84E-01	1.64E-04	2.79E-01
Fish and shellfish	1.95%	1.20E-04	9.18E-02	2.29E-03	2.29E-03
Fruit and vegetables	1.96%	1.36E-04	9.79E-02	5.49E-05	1.04E-01
Beverages	1.66%	1.08E-04	8.24E-02	1.21E-04	7.42E-02
Bread, grains and pasta	16.90%	6.45E-02	9.26E-01	6.69E-02	9.48E-01
Composite Foods	53.50%	6.63E-02	9.30E-01	3.93E-08	7.94E-01
Food infected by Humans or Animals	2.37%	1.10E-04	4.29E-02	1.70E-04	3.73E-02
	Number of experts	5		Entropy	2.63E+00
	Participating experts			Method	IPF

Clostridium perfringens					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	47.90%	2.09E-01	9.58E-01	1.96E-01	9.37E-01
Pork	8.38%	1.86E-04	7.41E-01	1.40E-04	6.45E-01
Chicken and poultry	7.13%	1.46E-04	5.34E-01	1.50E-04	5.44E-01
Eggs	2.83%	1.22E-04	9.32E-02	1.22E-04	9.47E-02
Dairy products	4.12%	1.23E-04	1.94E-01	1.30E-04	2.12E-01
Fish and shellfish	6.46%	2.11E-04	3.57E-01	2.18E-04	3.71E-01
Fruit and vegetables	6.89%	1.44E-04	3.48E-01	1.05E-04	3.50E-01
Beverages	2.45%	1.05E-04	8.27E-02	9.75E-05	8.33E-02
Bread, grains and pasta	2.64%	1.07E-04	9.59E-02	1.07E-04	9.32E-02
Composite Foods	7.67%	1.86E-04	5.63E-01	1.57E-04	5.31E-01
Food infected by Humans or Animals	3.57%	1.15E-04	1.82E-01	1.15E-04	1.83E-01
	Number of experts	4		Entropy	5.41E+00
	Participating experts			Method	IPF

Staphylococcus aureus					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	7.50%	4.19E-04	2.77E-01	4.21E-04	2.76E-01
Pork	8.10%	4.19E-04	2.91E-01	3.42E-04	2.94E-01
Chicken and poultry	7.76%	4.12E-04	2.90E-01	4.21E-04	2.85E-01
Eggs	3.32%	1.11E-04	9.85E-02	1.15E-04	9.80E-02
Dairy products	14.70%	5.26E-02	2.89E-01	2.81E-02	2.89E-01
Fish and shellfish	5.81%	4.21E-04	1.96E-01	4.21E-04	2.00E-01
Fruit and vegetables	2.00%	1.00E-04	4.71E-02	9.80E-05	4.70E-02
Beverages	1.82%	1.00E-04	4.19E-02	9.18E-05	4.31E-02
Bread, grains and pasta	7.49%	4.31E-04	2.95E-01	4.37E-04	2.94E-01
Composite Foods	29.60%	5.29E-02	4.88E-01	5.46E-02	4.88E-01
Food infected by Humans or Animals	11.90%	1.20E-04	7.87E-01	1.15E-04	7.72E-01
	Number of experts	4		Entropy	8.16E+00
	Participating experts			Method	IPF

Hepatitis A virus					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Beef and lamb	**0%**	0	0		
Pork	**0%**	0	0		
Chicken and poultry	**0%**	0	0		
Eggs	**0%**	0	0		
Dairy products	**0%**	0	0		
Fish and shellfish	**12.60%**	1.87E-04	3.91E-01	1.90E-04	3.98E-01
Fruit and vegetables	**12.70%**	1.66E-04	3.86E-01	1.67E-04	3.90E-01
Beverages	**4.38%**	1.00E-04	9.64E-02	9.77E-05	9.70E-02
Bread, grains and pasta	**4.44%**	1.00E-04	1.00E-01	9.61E-05	9.93E-02
Composite Foods	**3.05%**	1.00E-04	5.00E-02	1.02E-04	4.98E-02
Food infected by Humans or Animals	**62.80%**	1.07E-01	9.90E-01	1.07E-01	9.90E-01
	Number of experts	2		Entropy	8.66E+00
	Participating experts			Method	IPF

Hepatitis E virus					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	**95%**	**5%**	**95%**
Beef and lamb	**0%**				
Pork	**73.90%**	1.16E-01	9.97E-01	1.10E-01	9.95E-01
Chicken and poultry	**0%**				
Eggs	**0%**				
Dairy products	**0%**				
Fish and shellfish	**4.86%**	1.00E-04	1.00E-01	1.04E-04	1.05E-01
Fruit and vegetables	**7.44%**	1.00E-04	1.91E-01	1.00E-04	1.92E-01
Beverages	**3.51%**	1.00E-04	5.00E-02	1.02E-04	6.06E-02
Bread, grains and pasta	**0%**				
Composite Foods	**0%**				
Food infected by Humans or Animals	**10.30%**	1.77E-04	2.93E-01	1.84E-04	3.09E-01
	Number of experts	2		Entropy	8.64E+00
	Participating experts			Method	IPF

Norovirus					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	3.21%	1.00E-04	8.66E-02	8.77E-05	9.04E-02
Pork	3.13%	1.00E-04	9.50E-02	1.08E-04	9.47E-02
Chicken and poultry	2.92%	1.00E-04	8.53E-02	9.28E-05	8.52E-02
Eggs	1.93%	1.00E-04	4.68E-02	9.78E-05	4.76E-02
Dairy products	2.00%	1.00E-04	4.74E-02	9.60E-05	4.84E-02
Fish and shellfish	15.50%	5.45E-02	5.71E-01	5.46E-02	5.71E-01
Fruit and vegetables	7.32%	5.38E-04	4.34E-01	5.22E-04	4.10E-01
Beverages	3.05%	1.00E-04	8.53E-02	1.03E-04	8.63E-02
Bread, grains and pasta	5.16%	1.11E-04	1.88E-01	1.29E-04	1.90E-01
Composite Foods	4.95%	1.11E-04	1.87E-01	1.03E-04	1.87E-01
Food infected by Humans or Animals	50.80%	1.19E-01	8.87E-01	1.42E-01	8.74E-01
	Number of experts	5		Entropy	8.59E+00
	Participating experts			Method	IPF

Rotavirus					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	**0%**				
Pork	**2.83%**	1.00E-04	4.68E-02	1.07E-04	5.00E-02
Chicken and poultry	**0%**				
Eggs	**0%**				
Dairy products	**1.70%**	1.00E-04	1.76E-02	1.02E-04	1.76E-02
Fish and shellfish	**19.40%**	1.37E-04	5.86E-01	1.93E-04	5.90E-01
Fruit and vegetables	**23.80%**	2.22E-02	5.86E-01	2.24E-02	5.87E-01
Beverages	**4.38%**	1.00E-04	8.86E-02	1.06E-04	9.21E-02
Bread, grains and pasta	**7.49%**	1.00E-04	1.87E-01	1.13E-04	1.94E-01
Composite Foods	**4.50%**	1.14E-04	9.81E-02	1.28E-04	9.79E-02
Food infected by Humans or Animals	**35.90%**	5.35E-02	7.74E-01	5.15E-02	7.73E-01
	Number of experts	3		Entropy	7.49E+00
	Participating experts			Method	IPF

Cryptosporidium Parvum					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	**26.3%**	1.77E-04	5.82E-01	2.42E-01	5.85E-01
Pork	**4.4%**	1.00E-04	9.36E-02	2.12E-02	9.28E-02
Chicken and poultry	**2.9%**	1.00E-04	4.68E-02	1.47E-02	4.68E-02
Eggs	**2.7%**	1.00E-04	4.68E-02	1.22E-02	4.65E-02
Dairy products	**9.2%**	1.67E-04	1.96E-01	6.19E-02	1.97E-01
Fish and shellfish	**21.8%**	5.17E-02	3.83E-01	2.09E-01	3.82E-01
Fruit and vegetables	**20.7%**	5.17E-02	3.83E-01	1.95E-01	3.82E-01
Beverages	**3.0%**	1.00E-04	4.68E-02	1.25E-02	4.71E-02
Bread, grains and pasta	**0%**	0	0		
Composite Foods	**3.0%**	1.00E-04	4.68E-02	1.36E-02	4.67E-02
Food infected by Humans or Animals	**6.1%**	1.11E-02	9.77E-02	4.03E-02	1.08E-01
	Number of experts	2		Entropy	6.16E+00
	Participating experts			Method	IPF

Giardia lamblia					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	**19.70%**	1.31E-04	4.83E-01	1.27E-04	4.91E-01
Pork	**4.84%**	1.00E-04	9.33E-02	1.03E-04	9.32E-02
Chicken and poultry	**3.11%**	1.00E-04	4.40E-02	9.86E-05	4.58E-02
Eggs	**0%**	0	0		
Dairy products	**7.72%**	1.00E-04	1.79E-01	1.08E-04	1.79E-01
Fish and shellfish	**12.90%**	1.32E-04	2.84E-01	1.32E-04	2.83E-01
Fruit and vegetables	**33.00%**	2.94E-04	6.88E-01	2.84E-04	6.89E-01
Beverages	**3.15%**	1.00E-04	4.40E-02	9.53E-05	5.31E-02
Bread, grains and pasta	**0%**	0	0		
Composite Foods	**3.26%**	1.00E-04	4.84E-02	1.15E-04	4.83E-02
Food infected by Humans or Animals	**12.30%**	1.33E-04	2.93E-01	1.62E-04	3.04E-01
	Number of experts	3		Entropy	7.70E+00
	Participating experts			Method	IPF

Toxoplasma gondii					
Food Categories	Estimate Fraction	DM		Re-Sampling	
		5%	95%	5%	95%
Beef and lamb	**22.90%**	5.64E-02	4.77E-01	1.14E-03	4.71E-01
Pork	**50.20%**	2.20E-01	9.83E-01	2.14E-01	9.88E-01
Chicken and poultry	**4.82%**	1.09E-04	1.39E-01	1.12E-04	1.41E-01
Eggs	**0%**	0	0		
Dairy products	**4.59%**	1.09E-04	1.39E-01	1.11E-04	1.38E-01
Fish and shellfish	**3.65%**	1.14E-04	9.58E-02	1.19E-04	1.01E-01
Fruit and vegetables	**5.82%**	1.14E-04	1.78E-01	9.58E-05	1.84E-01
Beverages	**0%**	0	0		
Bread, grains and pasta	**0%**	0	0		
Composite Foods	**2.30%**	1.29E-04	4.95E-02	1.29E-04	4.95E-02
Food infected by Humans or Animals	**5.68%**	1.37E-04	1.91E-01	1.28E-04	1.90E-01
	Number of experts	3		Entropy	7.51E+00
	Participating experts			Method	IPF

APPENDIX B: Results Pathways

CAMPYLOBACTER											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**42.10%**	2.27E-01	8.52E-01	**50.60%**	2.27E-01	6.03E-01	8.52E-01				
Environment	**20.60%**	3.41E-04	7.31E-01	**14.70%**	3.41E-04	8.80E-02	7.31E-01				
Sick person	**6.28%**	1.45E-04	1.23E-01	**5.03%**	1.45E-04	3.30E-02	1.23E-01				
Animal Contact	**19.10%**	2.25E-03	5.98E-01	**17.40%**	2.25E-03	1.54E-01	5.98E-01				
Abroad	**12.00%**	2.00E-03	2.84E-01	**12.20%**	2.00E-03	1.21E-01	2.84E-01				

STEC O157											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**40.40%**	2.13E-01	8.35E-01	**43.40%**	2.13E-01	4.49E-01	8.35E-01				
Environment	**17.20%**	3.34E-04	4.66E-01	**17.30%**	3.34E-04	1.57E-01	4.66E-01				
Sick person	**10.20%**	3.29E-04	2.26E-01	**10.60%**	3.29E-04	9.95E-02	2.26E-01				
Animal Contact	**20.50%**	1.15E-03	7.61E-01	**19.30%**	1.15E-03	1.62E-01	7.61E-01				
Abroad	**11.70%**	2.63E-04	2.67E-01	**9.38%**	2.63E-04	6.09E-02	2.67E-01				

NON STEC O157											
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**42.60%**	2.08E-01	7.83E-01	**47.00%**	2.08E-01	4.96E-01	7.83E-01				
Environment	**14.50%**	1.35E-04	2.93E-01	**11.20%**	1.35E-04	7.11E-02	2.93E-01				
Sick person	**9.74%**	2.87E-04	1.96E-01	**10.80%**	2.87E-04	1.15E-01	1.96E-01				
Animal Contact	**27.60%**	1.07E-01	4.82E-01	**26.30%**	1.07E-01	2.50E-01	4.82E-01				
Abroad	**5.60%**	1.00E-04	9.81E-02	**4.63%**	1.00E-04	2.84E-02	9.81E-02				

LISTERIA MONOCYTOGENES											
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad						
			0								
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Food	**69.30%**	4.79E-01	9.90E-01	**74.10%**	4.68E-01	8.26E-01	9.90E-01	**73.10%**	4.52E-01	8.03E-01	9.73E-01
Environment	**6.73%**	1.99E-04	1.77E-01	**7.18%**	1.70E-04	6.14E-02	1.80E-01	**7.31%**	1.72E-04	6.06E-02	1.75E-01
Sick person	**5.25%**	1.76E-04	9.67E-01	**4.78%**	1.59E-04	2.62E-02	1.32E-01	**5.37%**	2.22E-04	3.35E-02	1.35E-01
Animal Contact	**5.35%**	2.94E-04	9.68E-01	**5.08%**	2.45E-04	3.30E-02	1.34E-01	**4.61%**	2.58E-04	2.91E-02	1.14E-01
Abroad	**13.40%**	1.19E-04	9.79E-01	**8.82%**	1.14E-04	2.56E-02	3.99E-01	**9.59%**	1.17E-04	2.98E-02	3.91E-01

MYCOBACTERIA AVIUM											
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**41.80%**	4.88E-04	7.91E-01	**34.90%**	5.22E-04	2.97E-01	7.84E-01				
Environment	**19.00%**	1.22E-04	5.76E-01	**24.10%**	1.81E-04	2.06E-01	5.82E-01				
Sick person	**18.30%**	1.96E-04	5.73E-01	**17.00%**	2.88E-04	4.87E-02	5.69E-01				
Animal Contact	**8.73%**	1.75E-04	2.72E-01	**10.80%**	1.71E-04	6.02E-02	2.70E-01				
Abroad	**12.20%**	3.47E-04	3.87E-01	**13.20%**	2.77E-04	6.77E-02	3.66E-01				

SALMONELLA											
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**54.60%**	3.32E-01	9.33E-01	**64.2%**	3.32E-01	7.43E-01	9.33E-01				
Environment	**12.90%**	1.70E-04	2.86E-01	**10.2%**	1.70E-04	7.05E-02	2.86E-01				
Sick person	**9.27%**	7.36E-05	1.79E-01	**6.2%**	7.36E-05	2.84E-02	1.79E-01				
Animal Contact	**9.23%**	3.93E-04	1.81E-01	**8.0%**	3.93E-04	6.17E-02	1.81E-01				
Abroad	**14.10%**	2.75E-02	2.56E-01	**11.5%**	2.75E-02	9.20E-02	2.56E-01				

BACILLUS CEREUS TOXIN											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
		0	0	0							
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Food	**89.30%**	8.09E-01	9.98E-01	**87.30%**	8.09E-01	9.39E-01	9.98E-01	**87.70%**	8.11E-01	9.49E-01	9.98E-01
Environment	**1.10%**	1.00E-04	4.06E-02	**0.74%**	1.00E-04	8.90E-04	4.06E-02	**0.82%**	1.00E-04	7.72E-04	3.47E-02
Sick person	**1.15%**	1.00E-04	3.95E-02	**0.71%**	1.00E-04	6.92E-04	3.95E-02	**0.70%**	1.00E-04	6.22E-04	3.27E-02
Animal Contact	**1.12%**	1.00E-04	3.95E-02	**0.74%**	1.00E-04	6.92E-04	3.95E-02	**0.72%**	1.00E-04	6.22E-04	3.27E-02
Abroad	**7.27%**	1.45E-04	9.12E-01	**10.50%**	1.45E-04	7.21E-02	9.12E-01	**10.10%**	1.29E-04	6.18E-02	8.69E-01

CLOSTRIDIUM PERFRINGENS TOXIN											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
		0	0	0							
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Food	**90.40%**	7.23E-01	9.96E-01	**88.50%**	7.23E-01	9.32E-01	9.96E-01	**89.00%**	7.44E-01	9.72E-01	9.92E-01
Environment	**2.19%**	1.13E-04	4.50E-02	**2.35%**	1.13E-04	1.04E-02	4.50E-02	**2.60%**	1.31E-04	1.22E-02	3.82E-02
Sick person	**2.08%**	1.13E-04	4.50E-02	**2.46%**	1.13E-04	1.04E-02	4.50E-02	**2.15%**	1.31E-04	1.22E-02	3.82E-02
Animal Contact	**2.09%**	1.13E-04	4.50E-02	**2.33%**	1.13E-04	1.04E-02	4.50E-02	**2.36%**	1.31E-04	1.22E-02	3.82E-02
Abroad	**3.24%**	1.31E-04	9.28E-02	**4.33%**	1.31E-04	2.87E-02	9.28E-02	**3.88%**	1.95E-04	2.90E-02	8.16E-02

STAPHYLOCOCUS AUREUS TOXIN												
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad							
		0	0	0								
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction				
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**	
Food	**87.30%**	7.27E-01	9.99E-01	**87.90%**	7.27E-01	9.24E-01	9.99E-01	**88.30%**	7.47E-01	9.33E-01	9.99E-01	
Environment	**3.60%**	1.08E-04	9.33E-02	**2.70%**	1.08E-04	9.05E-04	9.33E-02	**2.61%**	1.09E-04	8.70E-04	9.47E-02	
Sick person	**3.23%**	1.00E-04	8.33E-02	**2.50%**	1.00E-04	7.75E-04	8.33E-02	**2.17%**	1.00E-04	7.23E-04	7.04E-02	
Animal Contact	**2.15%**	1.00E-04	4.71E-02	**1.90%**	1.00E-04	2.46E-03	4.71E-02	**1.75%**	1.00E-04	1.44E-03	4.56E-02	
Abroad	**3.76%**	1.11E-04	9.85E-02	**5.05%**	1.11E-04	3.98E-02	9.85E-02	**5.13%**	1.15E-04	5.16E-02	9.86E-02	

ENTEROVIRUS												
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad							
				0								
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction				
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**	
Food	**6.26%**	1.00E-04	9.64E-02	**6.88%**	1.00E-04	2.68E-02	9.64E-02	**5.18%**	1.00E-04	2.59E-02	9.29E-02	
Environment	**24.60%**	1.68E-04	4.91E-01	**22.30%**	1.68E-04	8.00E-02	4.91E-01	**17.20%**	1.29E-04	3.50E-02	4.82E-01	
Sick person	**60.10%**	3.08E-01	9.27E-01	**60.30%**	3.08E-01	5.46E-01	9.27E-01	**67.30%**	3.17E-01	6.61E-01	9.39E-01	
Animal Contact	**2.18%**	1.00E-04	1.88E-02	**2.48%**	1.00E-04	7.68E-04	1.88E-02	**2.33%**	1.00E-04	6.50E-04	1.75E-02	
Abroad	**6.81%**	1.75E-04	1.48E-01	**7.97%**	1.75E-04	7.07E-02	1.48E-01	**8.02%**	1.32E-04	6.24E-02	1.45E-01	

HEPATITIS A VIRUS											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**11.40%**	5.00E-02	2.00E-01	**11.10%**	5.00E-02	1.25E-01	2.00E-01				
Environment	**11.10%**	5.00E-02	1.92E-01	**8.77%**	5.00E-02	8.47E-02	1.92E-01				
Sick person	**18.20%**	5.21E-02	8.95E-01	**20.80%**	5.21E-02	2.54E-01	8.95E-01				
Animal Contact	**0%**			**0%**							
Abroad	**59.30%**	5.10E-01	8.00E-01	**59.40%**	5.10E-01	6.78E-01	8.00E-01				

HEPATITIS E VIRUS											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
				0							
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Food	**13.80%**	1.00E-04	3.82E-01	**12.30%**	1.00E-04	5.61E-02	3.82E-01	**12.20%**	1.00E-04	5.55E-02	3.80E-01
Environment	**24.90%**	1.91E-04	9.45E-01	**29.90%**	1.91E-04	2.64E-01	9.45E-01	**24.60%**	2.06E-04	8.04E-01	9.45E-01
Sick person	**7.55%**	1.00E-04	1.91E-01	**6.83%**	1.00E-04	2.84E-02	1.91E-01	**8.51%**	1.00E-04	2.80E-02	1.90E-01
Animal Contact	**10.80%**	1.00E-04	2.85E-01	**8.92%**	1.00E-04	2.92E-02	2.85E-01	**11.60%**	1.00E-04	2.87E-02	2.83E-01
Abroad	**42.90%**	2.09E-01	6.83E-01	**42.00%**	2.09E-01	4.05E-01	6.83E-01	**43.00%**	2.10E-01	4.10E-01	6.84E-01

ROTAVIRUS											
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad						
				0							
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Food	**13.00%**	1.34E-02	2.84E-01	**12.50%**	1.34E-02	1.29E-01	2.84E-01	**16.50%**	1.00E-01	1.63E-01	2.90E-01
Environment	**17.00%**	2.51E-04	4.62E-01	**12.60%**	2.51E-04	8.96E-02	4.62E-01	**8.80%**	1.64E-04	5.00E-02	4.77E-01
Sick person	**58.10%**	4.28E-01	8.94E-01	**65.10%**	4.28E-01	7.31E-01	8.94E-01	**65.20%**	4.16E-01	8.00E-01	8.97E-01
Animal Contact	**3.03%**	1.00E-04	5.00E-02	**2.83%**	1.00E-04	2.50E-02	5.00E-02	**2.95%**	1.00E-04	2.50E-02	5.00E-02
Abroad	**8.86%**	1.65E-04	1.94E-01	**6.97%**	1.65E-04	5.00E-02	1.94E-01	**6.59%**	1.65E-04	5.00E-02	1.94E-01

NOROVIRUS											
	Food Ingestion	Environm ent	Contact with sick person	Direct animal contact	Contamin ation abroad						
				0							
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Food	**16.70%**	1.67E-02	5.34E-01	**15.50%**	1.67E-02	1.57E-01	5.34E-01	**19.20%**	1.01E-01	0.1775	5.41E-01
Environment	**14.20%**	5.03E-04	4.35E-01	**11.40%**	5.03E-04	1.13E-01	4.35E-01	**10.50%**	3.57E-04	0.1104	4.48E-01
Sick person	**55.50%**	4.19E-01	8.87E-01	**59.70%**	4.19E-01	6.83E-01	8.87E-01	**58.50%**	4.13E-01	0.6762	8.90E-01
Animal Contact	**4.95%**	1.00E-04	9.64E-02	**3.85%**	1.00E-04	2.68E-02	9.64E-02	**3.39%**	1.00E-04	0.02674	9.63E-02
Abroad	**8.70%**	3.71E-04	1.98E-01	**9.59%**	3.71E-04	1.10E-01	1.98E-01	**8.45%**	3.61E-04	0.1093	1.98E-01

CRYPTOSPORIDIUM PARUM											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**11.90%**	1.75E-04	1.95E-01	**12.80%**	1.75E-04	0.07419	1.95E-01				
Environment	**27.70%**	1.00E-01	3.84E-01	**26.30%**	1.00E-01	0.1695	3.84E-01				
Sick person	**27.40%**	1.00E-01	3.84E-01	**26.10%**	1.00E-01	0.1695	3.84E-01				
Animal Contact	**13.40%**	5.00E-02	1.92E-01	**14.20%**	5.00E-02	0.08474	1.92E-01				
Abroad	**19.60%**	4.50E-02	2.89E-01	**20.50%**	4.50E-02	0.1538	2.89E-01				

GIARDIA LAMBLIA											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Food	**13.00%**	1.36E-04	2.40E-01	**12.00%**	1.36E-04	7.77E-02	2.40E-01				
Environment	**23.90%**	1.03E-01	3.74E-01	**24.10%**	1.03E-01	2.09E-01	3.74E-01				
Sick person	**34.70%**	1.07E-01	5.63E-01	**35.40%**	1.07E-01	3.15E-01	5.63E-01				
Animal Contact	**10.70%**	3.12E-04	1.98E-01	**11.80%**	3.12E-04	1.00E-01	1.98E-01				
Abroad	**17.70%**	5.34E-02	2.82E-01	**16.80%**	5.34E-02	1.28E-01	2.82E-01				

TOXOPLASMA											
	Food Ingestion	Environment	Contact with sick person	Direct animal contact	Contamination abroad						
			0	0							
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Food	**55.80%**	3.24E-01	8.92E-01	**58.50%**	3.24E-01	5.65E-01	8.92E-01	**56.10%**	3.17E-01	5.30E-01	8.83E-01
Environment	**36.20%**	5.58E-02	6.61E-01	**30.90%**	5.58E-02	2.00E-01	6.61E-01	**34.40%**	6.16E-02	2.47E-01	6.71E-01
Sick person	**0.87%**	1.00E-04	8.86E-03	**1.80%**	1.00E-04	6.43E-04	8.86E-03	**1.41%**	1.00E-04	5.94E-04	7.84E-03
Animal Contact	**2.52%**	1.00E-04	2.64E-02	**2.10%**	1.00E-04	6.63E-04	2.64E-02	**1.67%**	1.00E-04	6.02E-04	2.32E-02
Abroad	**4.62%**	2.79E-04	9.95E-02	**6.66%**	2.79E-04	6.05E-02	9.95E-02	**6.36%**	2.21E-04	6.21E-02	9.97E-02

Results Food Categories

CAMPYLOBACTER											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
				0					0		
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**4.12%**	2.20E-04	1.64E-01	**6.44%**	2.20E-04	5.12E-02	1.64E-01	**6.66%**	2.40E-04	5.30E-02	1.65E-01
Pork	**5.08%**	3.06E-04	1.84E-01	**7.50%**	3.06E-04	6.11E-02	1.84E-01	**7.55%**	4.70E-04	5.96E-02	1.84E-01
Chicken	**53.90%**	1.72E-01	8.67E-01	**41.30%**	1.72E-01	4.23E-01	8.67E-01	**40.20%**	1.72E-01	3.97E-01	8.40E-01
Eggs	**3.05%**	1.11E-04	9.45E-02	**2.77%**	1.11E-04	6.69E-03	9.45E-02	**3.14%**	1.16E-04	8.91E-03	9.48E-02
Dairy	**8.92%**	5.27E-04	4.50E-01	**11.20%**	5.27E-04	6.88E-02	4.50E-01	**11.70%**	7.11E-04	6.57E-02	4.23E-01
Fish	**6.96%**	3.33E-04	2.71E-01	**8.75%**	3.33E-04	5.90E-02	2.71E-01	**8.92%**	3.17E-04	5.42E-02	2.72E-01
Fruit & Veg.	**5.31%**	2.10E-04	2.28E-01	**7.69%**	2.10E-04	5.20E-02	2.28E-01	**7.21%**	2.37E-04	4.29E-02	2.13E-01
Beverages	**1.71%**	1.03E-04	4.34E-02	**1.54%**	1.03E-04	2.57E-03	4.34E-02	**1.81%**	1.05E-04	4.90E-03	4.36E-02
Bread	**2.33%**	1.06E-04	6.46E-02	**1.91%**	1.06E-04	2.05E-03	6.46E-02	**2.17%**	1.11E-04	7.43E-03	4.99E-02
Composite	**3.31%**	1.33E-04	9.04E-02	**3.56%**	1.33E-04	1.78E-02	9.04E-02	**3.38%**	1.41E-04	1.65E-02	8.57E-02
Food Handler	**5.27%**	5.55E-04	1.75E-01	**7.30%**	5.55E-04	6.33E-02	1.75E-01	**7.20%**	5.16E-04	6.09E-02	1.68E-01

STEC O157											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
				0							
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**44.10%**	1.59E-01	8.75E-01	**43.80%**	1.59E-01	5.54E-01	8.75E-01	**44.60%**	1.59E-01	5.23E-01	8.57E-01
Pork	**6.36%**	1.34E-04	2.50E-01	**6.95%**	1.34E-04	3.40E-02	2.50E-01	**6.59%**	1.27E-04	3.40E-02	2.62E-01
Chicken	**3.06%**	1.13E-04	9.51E-02	**2.97%**	1.13E-04	1.71E-02	9.51E-02	**2.59%**	1.07E-04	1.00E-02	9.33E-02
Eggs	**2.11%**	1.00E-04	4.51E-02	**1.24%**	1.00E-04	7.82E-04	4.51E-02	**1.11%**	1.00E-04	6.60E-04	4.10E-02
Dairy	**7.40%**	4.00E-04	2.80E-01	**10.00%**	4.00E-04	7.40E-02	2.80E-01	**8.76%**	2.72E-04	7.28E-02	2.70E-01
Fish	**2.90%**	1.00E-04	7.85E-02	**2.40%**	1.00E-04	6.84E-03	7.85E-02	**2.26%**	1.00E-04	6.13E-03	8.27E-02
Fruit & Veg.	**7.06%**	4.00E-04	2.88E-01	**10.70%**	4.00E-04	1.12E-01	2.88E-01	**11.30%**	4.01E-04	1.20E-01	2.87E-01
Beverages	**3.57%**	1.18E-04	1.25E-01	**3.10%**	1.18E-04	1.58E-02	1.25E-01	**3.04%**	1.09E-04	7.36E-03	1.11E-01
Bread	**2.93%**	1.03E-04	8.53E-02	**1.72%**	1.03E-04	7.28E-04	8.53E-02	**1.72%**	1.02E-04	6.48E-04	7.97E-02
Composite	**3.55%**	1.14E-04	1.13E-01	**3.70%**	1.14E-04	2.99E-02	1.13E-01	**4.21%**	1.17E-04	3.13E-02	1.11E-01
Food Handler	**16.90%**	3.94E-04	8.73E-01	**13.40%**	3.94E-04	9.04E-02	8.73E-01	**13.80%**	3.92E-04	8.42E-02	8.64E-01

NON - O157										
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Beef	**61.70%**	3.04E-01	7.82E-01	**46.40%**	3.04E-01	4.49E-01	7.82E-01				
Pork	**8.71%**	1.32E-04	1.93E-01	**6.65%**	1.32E-04	5.03E-02	1.93E-01				
Chicken	**2.80%**	1.30E-04	9.70E-02	**4.56%**	1.30E-04	3.54E-02	9.70E-02				
Eggs	**1.14%**	1.00E-04	4.40E-02	**1.71%**	1.00E-04	6.69E-04	4.40E-02				
Dairy	**4.64%**	1.35E-04	2.44E-01	**8.61%**	1.35E-04	7.10E-02	2.44E-01				
Fish	**2.51%**	1.00E-04	5.00E-02	**2.95%**	1.00E-04	2.50E-02	5.00E-02				
Fruit & Veg.	**4.39%**	2.87E-04	1.99E-01	**10.60%**	2.87E-04	1.22E-01	1.99E-01				
Beverages	**3.81%**	1.14E-04	1.41E-01	**5.30%**	1.14E-04	1.97E-02	1.41E-01				
Bread	**2.23%**	1.00E-04	8.78E-02	**2.39%**	1.00E-04	6.77E-04	8.78E-02				
Composite	**2.19%**	1.00E-04	9.06E-02	**2.57%**	1.00E-04	1.80E-03	9.06E-02				
Food Handler	**5.85%**	2.83E-04	1.94E-01	**8.28%**	2.83E-04	8.17E-02	1.94E-01				

LISTERIA MONOCYTOGENES											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**11.20%**	5.11E-02	2.49E-01	**10.00%**	5.11E-02	9.63E-02	2.49E-01	**11.50%**	5.10E-02	9.71E-02	2.50E-01
Pork	**9.34%**	1.74E-03	5.52E-01	**11.60%**	1.74E-03	1.41E-01	5.52E-01	**13.00%**	6.26E-04	1.70E-01	5.57E-01
Chicken	**6.61%**	1.88E-04	1.71E-01	**6.57%**	1.88E-04	6.05E-02	1.71E-01	**5.41%**	1.24E-04	3.52E-02	1.39E-01
Eggs	**3.82%**	1.08E-04	9.02E-02	**1.89%**	1.08E-04	4.48E-03	9.02E-02	**3.32%**	1.00E-04	7.05E-04	6.23E-02
Dairy	**24.70%**	1.40E-01	6.88E-01	**29.20%**	1.40E-01	3.96E-01	6.88E-01	**21.60%**	1.22E-01	3.43E-01	5.71E-01
Fish	**17.80%**	1.05E-01	4.34E-01	**19.10%**	1.05E-01	2.19E-01	4.34E-01	**18.50%**	1.04E-01	2.02E-01	3.67E-01
Fruit & Veg.	**7.58%**	1.83E-04	2.50E-01	**6.64%**	1.83E-04	6.17E-02	2.50E-01	**8.98%**	1.63E-04	6.22E-02	2.71E-01
Beverages	**2.55%**	1.03E-04	4.09E-02	**1.00%**	1.03E-04	7.68E-04	4.09E-02	**2.17%**	1.00E-04	6.05E-04	2.93E-02
Bread	**5.90%**	1.21E-04	1.59E-01	**3.56%**	1.21E-04	2.87E-02	1.59E-01	**6.25%**	1.29E-04	3.75E-02	1.77E-01
Composite	**5.59%**	4.25E-04	1.92E-01	**7.65%**	4.25E-04	7.39E-02	1.92E-01	**7.00%**	2.08E-04	6.32E-02	1.90E-01
Food Handler	**4.87%**	1.12E-04	8.81E-02	**2.74%**	1.12E-04	1.68E-02	8.81E-02	**2.35%**	1.00E-04	6.03E-03	4.93E-02

MYCOBACTERIA AVIUM											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Beef	**6.0%**	1.61E-04	4.56E-01	**20.20%**	1.61E-04	0.1701	4.56E-01				
Pork	**41.1%**	1.54E-04	8.53E-01	**32.10%**	1.54E-04	0.06241	8.53E-01				
Chicken	**5.6%**	1.00E-04	4.71E-02	**2.92%**	1.00E-04	0.002457	4.71E-02				
Eggs	**2.4%**	1.00E-04	8.37E-03	**2.54%**	1.00E-04	0.000612	8.37E-03				
Dairy	**5.3%**	1.29E-04	1.96E-01	**10.40%**	1.29E-04	0.09449	1.96E-01				
Fish	**6.8%**	1.00E-04	8.60E-02	**3.75%**	1.00E-04	0.002741	8.60E-02				
Fruit & Veg.	**2.3%**	1.00E-04	8.92E-02	**5.53%**	1.00E-04	0.01351	8.92E-02				
Beverages	**5.1%**	1.00E-04	8.33E-02	**3.54%**	1.00E-04	0.000775	8.33E-02				
Bread	**1.4%**	1.00E-04	8.37E-03	**2.77%**	1.00E-04	0.000612	8.37E-03				
Composite	**3.6%**	1.17E-04	1.38E-01	**6.33%**	1.17E-04	0.0239	1.38E-01				
Food Handler	**20.3%**	1.59E-04	3.48E-01	**9.89%**	1.59E-04	0.05544	3.48E-01				

SALMONELLA											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**12.60%**	5.22E-02	2.84E-01								
Pork	**14.30%**	6.47E-02	4.73E-01								
Chicken	**14.80%**	7.78E-02	4.50E-01								
Eggs	**22.20%**	1.50E-01	5.43E-01								
Dairy	**6.54%**	2.51E-04	2.47E-01								
Fish	**4.09%**	1.18E-04	9.61E-02								
Fruit & Veg.	**6.33%**	2.74E-04	2.04E-01								
Beverages	**3.14%**	1.04E-04	8.46E-02								
Bread	**4.26%**	1.11E-04	1.21E-01								
Composite	**6.01%**	4.77E-04	1.78E-01								
Food Handler	**5.71%**	1.43E-03	1.77E-01								

BACILLUS CERUS TOXIN											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**7.17%**	1.45E-04	1.80E-01	**6.3%**	1.45E-04	6.47E-02	1.80E-01	**7.70%**	1.93E-04	7.72E-02	1.96E-01
Pork	**3.45%**	1.44E-04	1.77E-01	**4.9%**	1.44E-04	3.27E-02	1.77E-01	**7.99%**	1.93E-04	7.72E-02	1.96E-01
Chicken	**1.63%**	1.21E-04	9.67E-02	**3.2%**	1.21E-04	1.87E-02	9.67E-02	**1.82%**	1.00E-04	5.83E-03	4.77E-02
Eggs	**3.63%**	1.20E-04	1.82E-01	**4.1%**	1.20E-04	1.06E-02	1.82E-01	**1.89%**	1.00E-04	5.83E-03	4.81E-02
Dairy	**5.76%**	1.39E-04	2.84E-01	**5.4%**	1.39E-04	1.50E-02	2.84E-01	**3.58%**	1.36E-04	9.09E-03	1.91E-01
Fish	**1.95%**	1.20E-04	9.18E-02	**2.7%**	1.20E-04	1.05E-02	9.18E-02	**1.78%**	1.00E-04	5.83E-03	4.77E-02
Fruit & Veg.	**1.96%**	1.36E-04	9.79E-02	**4.0%**	1.36E-04	3.20E-02	9.79E-02	**2.56%**	1.00E-04	6.09E-03	9.34E-02
Beverages	**1.66%**	1.08E-04	8.24E-02	**2.8%**	1.08E-04	7.11E-03	8.24E-02	**2.00%**	1.00E-04	6.09E-03	9.34E-02
Bread	**16.90%**	6.45E-02	9.26E-01	**29.5%**	6.45E-02	3.42E-01	9.26E-01	**21.30%**	5.05E-02	1.60E-01	5.75E-01
Composite	**53.50%**	6.63E-02	9.30E-01	**35.6%**	6.63E-02	4.49E-01	9.30E-01	**47.70%**	1.11E-01	6.17E-01	8.89E-01
Food Handler	**2.37%**	1.10E-04	4.29E-02	**1.5%**	1.10E-04	5.87E-03	4.29E-02	**1.70%**	1.00E-04	5.83E-03	4.69E-02

CLOSTRIDIUM PERFRINGENS TOXIN											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
				0				0	0		0
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**47.90%**	2.09E-01	9.58E-01	**37.30%**	2.09E-01	5.02E-01	9.58E-01	**39.60%**	2.15E-01	5.21E-01	6.00E-01
Pork	**8.38%**	1.86E-04	7.41E-01	**14.30%**	1.86E-04	2.28E-01	7.41E-01	**3.33%**	1.21E-04	5.17E-02	9.82E-02
Chicken	**7.13%**	1.46E-04	5.34E-01	**9.10%**	1.46E-04	9.90E-02	5.34E-01	**6.58%**	1.21E-04	8.12E-02	1.18E-01
Eggs	**2.83%**	1.22E-04	9.32E-02	**2.99%**	1.22E-04	1.50E-02	9.32E-02	**0.88%**	1.20E-04	1.04E-02	1.97E-02
Dairy	**4.12%**	1.23E-04	1.94E-01	**4.82%**	1.23E-04	4.85E-02	1.94E-01	**7.94%**	1.16E-04	9.55E-04	1.94E-01
Fish	**6.46%**	2.11E-04	3.57E-01	**7.06%**	2.11E-04	7.24E-02	3.57E-01	**24.60%**	1.00E-01	1.67E-01	3.90E-01
Fruit & Veg.	**6.89%**	1.44E-04	3.48E-01	**5.54%**	1.44E-04	3.30E-02	3.48E-01	**9.56%**	2.02E-02	3.86E-02	3.83E-01
Beverages	**2.45%**	1.05E-04	8.27E-02	**1.07%**	1.05E-04	7.69E-04	8.27E-02	**0.71%**	1.00E-04	5.50E-04	1.00E-03
Bread	**2.64%**	1.07E-04	9.59E-02	**1.58%**	1.07E-04	2.22E-03	9.59E-02	**0.23%**	1.00E-04	5.50E-04	1.00E-03
Composite	**7.67%**	1.86E-04	5.63E-01	**13.60%**	1.86E-04	1.90E-01	5.63E-01	**4.59%**	1.21E-04	5.29E-02	1.46E-01
Food Handler	**3.57%**	1.15E-04	1.82E-01	**2.73%**	1.15E-04	1.11E-02	1.82E-01	**1.99%**	1.15E-04	9.46E-04	4.73E-02

STAPHYLOCOCUS AUREUS TOXIN											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
				0				0	0		0
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**7.50%**	4.19E-04	2.77E-01	**10.90%**	4.19E-04	9.08E-02	2.77E-01	**4.91%**	1.70E-04	9.55E-02	1.98E-01
Pork	**8.10%**	4.19E-04	2.91E-01	**9.60%**	4.19E-04	9.08E-02	2.91E-01	**5.52%**	1.70E-04	9.55E-02	2.92E-01
Chicken	**7.76%**	4.12E-04	2.90E-01	**9.84%**	4.12E-04	8.44E-02	2.90E-01	**5.06%**	1.69E-04	7.66E-02	2.89E-01
Eggs	**3.32%**	1.11E-04	9.85E-02	**4.16%**	1.11E-04	3.98E-02	9.85E-02	**3.20%**	1.00E-04	8.39E-04	9.40E-02
Dairy	**14.70%**	5.26E-02	2.89E-01	**14.70%**	5.26E-02	1.35E-01	2.89E-01	**16.40%**	1.00E-01	1.63E-01	2.91E-01
Fish	**5.81%**	4.21E-04	1.96E-01	**8.13%**	4.21E-04	8.82E-02	1.96E-01	**5.32%**	1.71E-04	9.55E-02	1.97E-01
Fruit & Veg.	**2.00%**	1.00E-04	4.71E-02	**1.60%**	1.00E-04	2.46E-03	4.71E-02	**1.97%**	1.00E-04	8.18E-04	4.70E-02
Beverages	**1.82%**	1.00E-04	4.19E-02	**1.34%**	1.00E-04	7.67E-04	4.19E-02	**0.24%**	1.00E-04	5.50E-04	1.00E-03
Bread	**7.49%**	4.31E-04	2.95E-01	**10.50%**	4.31E-04	1.01E-01	2.95E-01	**22.80%**	1.01E-01	2.32E-01	3.00E-01
Composite	**29.60%**	5.29E-02	4.88E-01	**20.10%**	5.29E-02	1.61E-01	4.88E-01	**33.00%**	1.03E-01	4.00E-01	4.96E-01
Food Handler	**11.90%**	1.20E-04	7.87E-01	**9.09%**	1.20E-04	3.18E-02	7.87E-01	**1.61%**	1.00E-04	2.50E-02	5.00E-02

HEPATITIS A VIRUS											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef											
Pork											
Chicken											
Eggs											
Dairy											
Fish	**12.60%**	1.87E-04	3.91E-01		1.87E-04	1.48E-01	3.91E-01				
Fruit & Veg.	**12.70%**	1.66E-04	3.86E-01		1.66E-04	6.04E-02	3.86E-01				
Beverages	**4.38%**	1.00E-04	9.64E-02		1.00E-04	2.68E-02	9.64E-02				
Bread	**4.44%**	1.00E-04	1.00E-01		1.00E-04	5.00E-02	1.00E-01				
Composite	**3.05%**	1.00E-04	5.00E-02		1.00E-04	2.50E-02	5.00E-02				
Food Handler	**62.80%**	1.07E-01	9.90E-01		1.07E-01	4.37E-01	9.90E-01				

HEPATITIS E VIRUS											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Beef	**73.90%**	1.16E-01	9.97E-01	**71.50%**	1.16E-01	8.16E-01	9.97E-01				
Pork	**0%**			**0%**							
Chicken	**0%**			**0%**							
Eggs	**0%**			**0%**							
Dairy	**4.86%**	1.00E-04	1.00E-01	**5.92%**	1.00E-04	5.00E-02	1.00E-01				
Fish	**7.44%**	1.00E-04	1.91E-01	**6.81%**	1.00E-04	2.84E-02	1.91E-01				
Fruit & Veg.	**3.51%**	1.00E-04	5.00E-02	**3.78%**	1.00E-04	2.50E-02	5.00E-02				
Beverages	**0%**			**0%**							
Bread	**0%**			**0%**							
Composite	**0%**			**0%**							
Food Handler	**10.30%**	1.77E-04	2.93E-01	**12.00%**	1.77E-04	1.00E-01	2.93E-01				

NOROVIRUS											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
			0								
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**3.21%**	1.00E-04	8.66E-02	**1.87%**	1.00E-04	3.42E-03	8.66E-02	**1.67%**	1.00E-04	9.67E-04	4.42E-02
Pork	**3.13%**	1.00E-04	9.50E-02	**1.97%**	1.00E-04	4.99E-03	9.50E-02	**2.86%**	1.00E-04	9.81E-04	9.11E-02
Chicken	**2.92%**	1.00E-04	8.53E-02	**1.54%**	1.00E-04	8.08E-04	8.53E-02	**0.92%**	1.00E-04	6.27E-04	4.24E-02
Eggs	**1.93%**	1.00E-04	4.68E-02	**1.44%**	1.00E-04	7.99E-04	4.68E-02	**1.30%**	1.00E-04	6.27E-04	4.13E-02
Dairy	**2.00%**	1.00E-04	4.74E-02	**0.98%**	1.00E-04	3.01E-03	4.74E-02	**1.00%**	1.00E-04	9.67E-04	4.29E-02
Fish	**15.50%**	5.45E-02	5.71E-01	**22.80%**	5.45E-02	2.55E-01	5.71E-01	**32.70%**	6.93E-02	3.88E-01	5.90E-01
Fruit & Veg.	**7.32%**	5.38E-04	4.34E-01	**15.20%**	5.38E-04	2.14E-01	4.34E-01	**21.70%**	3.94E-04	2.47E-01	4.85E-01
Beverages	**3.05%**	1.00E-04	8.53E-02	**1.32%**	1.00E-04	8.08E-04	8.53E-02	**2.68%**	1.00E-04	1.25E-03	9.20E-02
Bread	**5.16%**	1.11E-04	1.88E-01	**4.80%**	1.11E-04	2.61E-02	1.88E-01	**2.63%**	1.00E-04	9.81E-04	9.26E-02
Composite	**4.95%**	1.11E-04	1.87E-01	**3.38%**	1.11E-04	2.27E-02	1.87E-01	**1.05%**	1.00E-04	1.06E-03	4.86E-02
Food Handler	**50.80%**	1.19E-01	8.87E-01	**44.60%**	1.19E-01	5.31E-01	8.87E-01	**31.50%**	1.08E-01	2.99E-01	8.73E-01

ROTAVIRUS											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Beef	**0%**			**0%**							
Pork	**2.79%**	1.00E-04	4.68E-02	**2.87%**	1.00E-04	7.99E-04	4.68E-02				
Chicken	**0%**			**0%**							
Eggs	**0%**			**0%**							
Dairy	**1.74%**	1.00E-04	1.76E-02	**1.48%**	1.00E-04	6.56E-04	1.76E-02				
Fish	**19.40%**	1.37E-04	5.86E-01	**20.30%**	1.37E-04	1.31E-01	5.86E-01				
Fruit & Veg.	**23.80%**	2.22E-02	5.86E-01	**26.70%**	2.22E-02	2.82E-01	5.86E-01				
Beverages	**4.35%**	1.00E-04	8.86E-02	**3.51%**	1.00E-04	1.10E-03	8.86E-02				
Bread	**7.35%**	1.00E-04	1.87E-01	**4.73%**	1.00E-04	8.32E-04	1.87E-01				
Composite	**4.59%**	1.14E-04	9.81E-02	**4.95%**	1.14E-04	3.30E-02	9.81E-02				
Food Handler	**36.00%**	5.35E-02	7.74E-01	**35.50%**	5.35E-02	2.91E-01	7.74E-01				

CRYPTOSPORIDIUM PARVUM											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
								0			
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**26.3%**	1.77E-04	5.82E-01	**25.10%**	1.77E-04	1.18E-01	5.82E-01	**29.40%**	3.10E-04	2.85E-01	5.92E-01
Pork	**4.4%**	1.00E-04	9.36E-02	**6.29%**	1.00E-04	8.17E-04	9.36E-02	**3.02%**	1.00E-04	6.68E-04	8.70E-02
Chicken	**2.9%**	1.00E-04	4.68E-02	**4.42%**	1.00E-04	7.99E-04	4.68E-02	**2.06%**	1.00E-04	6.61E-04	4.36E-02
Eggs	**2.7%**	1.00E-04	4.68E-02	**3.71%**	1.00E-04	7.99E-04	4.68E-02	**1.99%**	1.00E-04	6.61E-04	4.36E-02
Dairy	**9.2%**	1.67E-04	1.96E-01	**8.08%**	1.67E-04	5.82E-02	1.96E-01	**10.10%**	2.75E-04	1.23E-01	1.98E-01
Fish	**21.8%**	5.17E-02	3.83E-01	**19.30%**	5.17E-02	1.00E-01	3.83E-01	**21.70%**	5.35E-02	1.61E-01	3.92E-01
Fruit & Veg.	**20.7%**	5.17E-02	3.83E-01	**18.00%**	5.17E-02	1.00E-01	3.83E-01	**20.00%**	5.35E-02	1.61E-01	3.92E-01
Beverages	**3.0%**	1.00E-04	4.68E-02	**3.11%**	1.00E-04	7.99E-04	4.68E-02	**2.17%**	1.00E-04	6.61E-04	4.36E-02
Bread	**0%**			**0%**				**0%**			
Composite	**3.0%**	1.00E-04	4.68E-02	**3.70%**	1.00E-04	7.99E-04	4.68E-02	**3.13%**	1.00E-04	6.61E-04	4.36E-02
Food Handler	**6.1%**	1.11E-02	9.77E-02	**8.29%**	1.11E-02	5.00E-02	9.77E-02	**6.39%**	1.05E-02	3.82E-02	9.53E-02

GIARIDA LAMBLIA											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
	Estimate Fraction	DM		Estimate Fraction							
		5%	**95%**		**5%**	**50%**	**95%**				
Beef	**19.70%**	1.31E-04	4.83E-01	**18.30%**	1.31E-04	3.57E-02	4.83E-01				
Pork	**4.84%**	1.00E-04	9.33E-02	**5.78%**	1.00E-04	2.59E-02	9.33E-02				
Chicken	**3.11%**	1.00E-04	4.40E-02	**3.16%**	1.00E-04	6.69E-04	4.40E-02				
Eggs	**0%**			**0%**							
Dairy	**7.72%**	1.00E-04	1.79E-01	**5.42%**	1.00E-04	2.07E-03	1.79E-01				
Fish	**12.90%**	1.32E-04	2.84E-01	**13.00%**	1.32E-04	5.03E-02	2.84E-01				
Fruit & Veg.	**33.00%**	2.94E-04	6.88E-01	**35.90%**	2.94E-04	2.96E-01	6.88E-01				
Beverages	**3.15%**	1.00E-04	4.40E-02	**3.13%**	1.00E-04	6.69E-04	4.40E-02				
Bread	**0%**			**0%**							
Composite	**3.26%**	1.00E-04	4.84E-02	**3.91%**	1.00E-04	1.54E-03	4.84E-02				
Food Handler	**12.30%**	1.33E-04	2.93E-01	**11.40%**	1.33E-04	5.06E-02	2.93E-01				

TOXOPLASMA											
	Beef and lamb	Pork	Chicken and poultry	Eggs	Dairy products	Fish and shellfish	Fruit and vegetable	Beverages	Bread, grains and pasta	Composite Foods	Food Handler
			0		0						0
	Estimate Fraction	DM		Estimate Fraction				Estimate Fraction			
		5%	**95%**		**5%**	**50%**	**95%**		**5%**	**50%**	**95%**
Beef	**22.90%**	5.64E-02	4.77E-01	**23.00%**	5.64E-02	2.51E-01	4.77E-01	**18.20%**	5.31E-02	1.47E-01	3.91E-01
Pork	**50.20%**	2.20E-01	9.83E-01	**53.90%**	2.20E-01	6.01E-01	9.83E-01	**70.00%**	4.09E-01	9.01E-01	9.87E-01
Chicken	**4.82%**	1.09E-04	1.39E-01	**2.19%**	1.09E-04	7.57E-04	1.39E-01	**0%**	1.00E-04	5.50E-04	1.00E-03
Eggs	**0%**			**0%**				**0%**			
Dairy	**4.59%**	1.09E-04	1.39E-01	**3.07%**	1.09E-04	7.57E-04	1.39E-01	**0%**	1.00E-04	5.50E-04	1.00E-03
Fish	**3.65%**	1.14E-04	9.58E-02	**4.67%**	1.14E-04	1.93E-02	9.58E-02	**1.19%**	1.00E-04	7.81E-04	4.71E-02
Fruit & Veg.	**5.82%**	1.14E-04	1.78E-01	**4.07%**	1.14E-04	1.26E-02	1.78E-01	**5.65%**	1.84E-04	2.72E-02	1.90E-01
Beverages	**0%**			**0%**				**0%**			
Bread	**0%**			**0%**				**0%**			
Composite	**2.30%**	1.29E-04	4.95E-02	**3.23%**	1.29E-04	2.50E-02	4.95E-02	**1.19%**	1.67E-04	2.50E-02	4.90E-02
Food Handler	**5.68%**	1.37E-04	1.91E-01	**5.81%**	1.37E-04	2.86E-02	1.91E-01	**5.65%**	1.18E-04	1.03E-02	4.83E-02

APPENDIX B

SALMONELLA (Pathways)

Expert's Information

Name

email address

For each event, please specify an interval which contains the probability of occurrence with 90% certainty.

		MINIMUM		MAXIMUM	
1 . A case of illness due to Salmonella was transmitted by food ingestion	0% ≤		≤		≤ 100%
2 . A case of illness due to Salmonella was transmitted through the environment.	0% ≤		≤		≤ 100%
3 . A case of illness due to Salmonella was transmitted by contact with a sick person	0% ≤		≤		≤ 100%
4 . A case of illness due to Salmonella was transmitted by direct animal contact	0% ≤		≤		≤ 100%
5 . A case of illness due to Salmonella was transmitted abroad by any pathway.	0% ≤		≤		≤ 100%

Salmonella (Food Categories)

Expert's Information

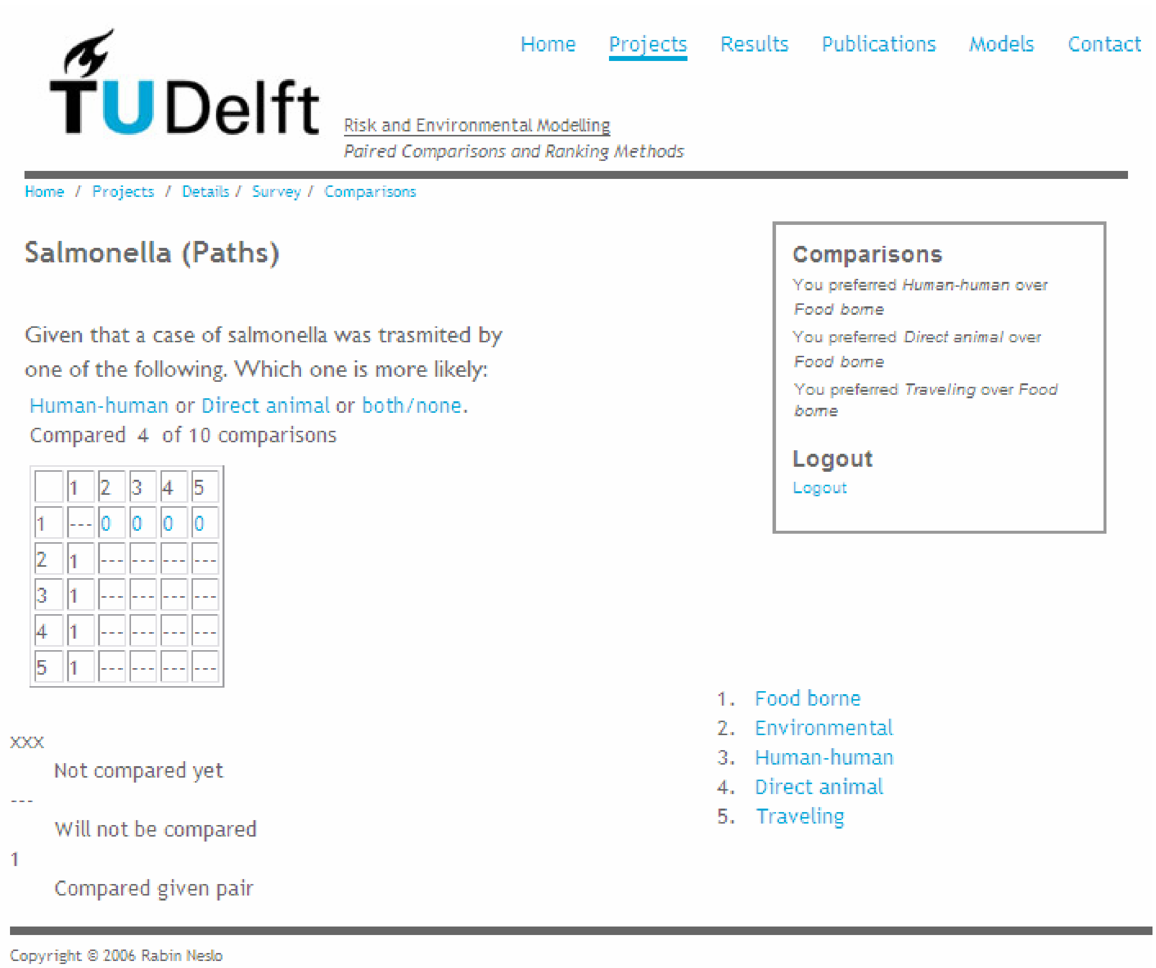
Name

email address

For each event, please specify an interval which contains the probability of occurrence with 90% certainty.

			MINIMUM		MAXIMUM	
1.	A case of illness due to Salmonella was transmitted by ingestion of Beef and lamb	0% ≤		≤		≤ 100%
2.	A case of illness due to Salmonella was transmitted by ingestion of Pork	0% ≤		≤		≤ 100%
3.	A case of illness due to Salmonella was transmitted by ingestion of Chicken and other poultry	0% ≤		≤		≤ 100%
4.	A case of illness due to Salmonella was transmitted by ingestion of Eggs	0% ≤		≤		≤ 100%
5.	A case of illness due to Salmonella was transmitted by ingestion of Dairy products	0% ≤		≤		≤ 100%
6.	A case of illness due to Salmonella was transmitted by ingestion of Fish and shellfish	0% ≤		≤		≤ 100%
7.	A case of illness due to Salmonella was transmitted by ingestion of 7. Fruit and vegetables	0% ≤		≤		≤ 100%
8.	A case of illness due to Salmonella was transmitted by ingestion of Beverages	0% ≤		≤		≤ 100%
9.	A case of illness due to Salmonella was transmitted by ingestion Bread, grains, pastas and bakery products	0% ≤		≤		≤ 100%
10	A case of illness due to Salmonella was transmitted by ingestion other foods including composite foods	0% ≤		≤		≤ 100%
11	A case of illness due to Salmonella was transmitted by ingestion of food infected by humans or animals	0% ≤		≤		≤ 100%

APPENDIX C



Home Projects Results Publications Models Contact

TU Delft

Risk and Environmental Modelling

Paired Comparisons and Ranking Methods

Home / Projects / Details / Survey / Comparisons

Salmonella (Paths)

Given that a case of salmonella was trasmited by one of the following. Which one is more likely:

Human-human or Direct animal or both/none.

Compared 4 of 10 comparisons

	1	2	3	4	5
1	---	0	0	0	0
2	1	---	---	---	---
3	1	---	---	---	---
4	1	---	---	---	---
5	1	---	---	---	---

xxx
Not compared yet

Will not be compared

1
Compared given pair

Comparisons

You preferred *Human-human* over *Food borne*

You preferred *Direct animal* over *Food borne*

You preferred *Traveling* over *Food borne*

Logout

Logout

1. Food borne
2. Environmental
3. Human-human
4. Direct animal
5. Traveling

BIBLIOGRAPHY

Batz M.B, Doyle M.P, Morris J.G, Painter J. Singh R, Tauxe R.V, Taylor M.R, Lo Fo Wong D. *Attribution Illness to Food. Food Attribution Working Group*. 2005; 993-999.

Bedford, T. and Cooke R.M. *Probabilistic Risk Analysis: Foundations and Methods.* Cambridge University Press, 2001.

Cooke, R.M. Experts in Uncertainty. Opinion and Subjective Probability in Science. Oxford University Press. 1991.

Cooke, R.M. *Parameter fitting for uncertain models: modeling uncertainty in small models*. Reliab. Engrg. System Safe. 44, Pg. 89–102. 1994

Cooke, R. M., Nauta M., Havelaar, A. H., van der Fels, I. Probabilistic Inversion for Chicken Processing Lines. Department of Mathematics Delft University of Technology Delft. Microbiological Laboratory for Health Protection RIVM ,Bilthoven, The Netherlands

Cooke, R.M., Goossens, L.H.J., 2000. *Procedures guide for structured expert judgement in accident consequence modelling*. Radiat. Prot. Dosim. 90 (3), 303–309.

Hoffman S, Fishbeck P, Krupnick A, McWilliams M. *Eliciting Information on Uncertainty from Heterogeneous Expert Panels: Attributing U. S. Foodborne Pathogens Illness to Food Consumption*. Resources for the Future. 2006.

Hoffman S, Fishbeck P, Krupnick A, McWilliams M. Informing Risk-Mitigation Priorities Using Uncertainty Measures Derived from Heterogeneous Expert Panels: A Demonstration Using Foodborne Pathogens. 2006.

Knaap A.G.A.C., van Kreijl C.F, van Raaij J.M.A. Our food, our health: Healthy diet and safe food in the Netherland. RIVM. The Netherlands. 2006.

Kemmeren J.M, Mangen M.-J.J, van Duynhoven Y.T.H.P, Havelaar A.H. *Priority Setting of Foodborne Pathogens, Disease Burden and Costs of Selected Enteric Pathogens.* Rijksinstituut voor Volksegezondheid en Milieu. 2006.

Kurowicka, D. and Cooke, R.M. T*echniques for Generic Probabilistic Inversion.* Probabilistic Safety Assessment and Management. Elsevier. Pg. ;1543-1550. 2002

Kurodwicka, D. Cooke, R.M. Uncertainty Analysis with High Dimensional Dependence Modeling. 2006

Macutkiewicz M. *Paired Comparisons and Group Preference*. TUDelft. 2006.

World Health Organization. *Electronic sources:* Food safety and foodborne illness. <http://www.who.int/mediacentre/factsheets/fs237/en/>