Appendix 6.
Software

Appendix 6: Software

This section contains a description of some of the software routines used in preparing the *Listeria* risk assessment. These were developed by the agency to deal with recurring risk assessments problems

A. The Dose Frequency Curve-Fitting Program

This routine takes a data set that contains historical records of an association between a continuous measure and the frequency of occurrence of a discrete event in a population. It is similar in operation to ParamFit, except that it is designed to be used with data sets that correlate a dose with an outcome, rather than a simple distribution. After fitting one of more models to the data, the parameters are written to a file that may be used with the DoseFrequency object. The parameter file may also be examined with the DoseFrequency plotting routine, or the parameter estimates may examined in Excel and used without the object.

Data

In order to proceed, the routine must be supplied with data in the proper format. There are two ways to do that.

The first is to supply a data file that is in the correct format. The “File Open” button may be used to browse for the file name. The file is not actually opened unless the “Data Edit” or “Run” buttons are selected. Alternatively, the file name, including the path, may be entered into the text box to the right of the “File Open” button.

Alternatively, data may be entered using the “Data Editor,” which is started with the “Data Edit” button. If a file name has already been entered the Data Editor will open this data file. If it has not, then the “Editor” begins with no entries.

Choosing Models

The models used by the DoseFrequency curve-fitting routine have 1 to 3 components. The total number of models fit will be equal to the number of possible permutations of each of the three components selected

The mandatory component is the primary dose-response function listed in the “Models-to-be-Fit” box. At least one model must be selected for the program to proceed. However, any combination may be selected. The curve-fitting routine will attempt to fit all models selected. A description of the models currently supported is given below.

Models currently supported by the DF curve-fitting program and object:

Model Name	**Parameters**	**Equation for Frequency Given Dose**
Beta Poisson	alpha, beta	1 - ((1 + (dose / beta) alpha)
Logistic	alpha, beta	$e^{alpha + beta *ln(dose)} / (1 + e^{alpha + beta * ln(dose))}$
Exponential	slope	$1 - e^{-dose * slope}$
Gompertz – Log	alpha, beta	$1 - e^{-e \hat{} (alpha + (beta *ln(dose)))}$
Gompertz – Power	alpha, beta, power	$1 – e^{-e \hat{} (alpha + (beta * (dose\hat{}power)))}$
Probit	alpha, beta	normal_cdf(alpha + beta*ln(dose))
Multihit	gamma, k	gamma_cdf(gamma*dose, k)
GammaWeibull	alpha, beta, gamma	$1 - (1 + (dose^{gamma/beta})–alpha)$

Ln = natural log. cdf = cumulative distribution function. ^ = raised to the power of

Background Parameter

A parameter may be added to the model to accommodate other influences on the outcome of the causal event. There are three options:

- No background parameter.
- Background Dose. A background dose specified by an extra model parameter is added to the nominal dose when predicting frequency.
- Background Frequency. A background frequency specified by an extra model parameter is added to the predicted frequency. The dose-frequency function is applied to the fraction of the population who would otherwise not respond.

The program will attempt to fit all options that are checked. For example, if all three boxes are checked, then the program will examine all three different options. At least one box must be checked.

If there are fewer than five data points, then a Background Parameter cannot be employed.

Threshold Parameter

If a threshold dose parameter is included in the model, and if the nominal dose is less than the threshold dose value, then the effective dose used to predict frequency is zero. If the nominal dose is greater than the threshold dose value, then the effective dose used to predict frequency is the nominal dose minus the threshold dose. The program attempts to fit all options that are checked. If both boxes are checked, then the program examines both options. At least one box must be checked. If there are fewer than five data points, then a “Threshold Parameter” cannot be employed.

Options

Selecting the “Options” button opens another dialog, which gives the user some additional choices regarding how the routine operates. These include choosing the goodness-of-fit measure, how the program weights models when creating a probability tree, and the initial estimates for each of the model parameters.

Bootstraps

In order to represent uncertainty arising from sampling error, dose measurement error, or the size of the exposed population in which illnesses are observed, multiple bootstraps may be performed. Sampling error, where the small sample of observed values is presumed to come from a much larger sample that is of interest, is represented by presuming a binomial distribution where the total set of values is infinitely large. The likelihood of a series of possible values for the actual frequency are computed by comparing the relative likelihood of generating the observed value. Dose and population size measurement error are sampled from distributions supplied with the data set. The total number of models fit equals the number of models selected times the number of bootstraps. While very large numbers are possible, the program has not been tested with more than 10,000 models.

Initial Parameter Estimates

The default initial parameter estimates that are used by the IMSL nonlinear regression program to produce an optimum fit may not work well for all data sets. The initial estimate for the primary functions can be changed in this dialog. Initial estimates for the threshold and background parameters cannot be changed at this time. Selecting "OK" results in retention of the new parameter estimate. Selecting "Cancel" will not.

Model Weighting

Even if bootstrapping is selected, the first bootstrap (the first set of models in the parameter file) always uses the original data.

Run

The routine begins by fitting curves when the "Run" button is selected. The "Parameter File" dialog appears when the routine is finished. A progress bar displays the percentage of the task that has been completed. However, unless bootstrapping is selected, the results are nearly instantaneous. Selecting the "Cancel" button causes the program to exit.

As the program fits the alternative models to the data set, it calculates a weight for each of the models that is used by the object to assign probabilities to each of the models. The weighting algorithm used by the program rewards models for goodness of fit, and penalizes for parameters. Moving the slider bar to the left increases the importance of producing a good fit, while moving it to the right emphasizes the use of fewer parameters.

When bootstraps are run, the weights are recalculated on a relative basis for each bootstrap, so that the total weight for each bootstrap is identical. This means if the routine is used soley to represent the uncertainty in the parameters for a given model (*i. e.*, parameter uncertainty with no model uncertainty), then the model weighting algorithm has no effect.

ParamFit

ParamFit is a procedure for fitting a statistical distribution to a set of individual values for use in a subsequent Monte-Carlo simulation. It is similar in function to the routine included with Crystal Ball (Decisioneering) or BestFit, the add-on sold by Palisade as a companion to @Risk. The principle difference is that ParamFit is specifically intended for use in a population modeling exercise (*e. g*., public health). In this circumstance, the primary purpose of a distribution is to represent variability in the measured quantity among individuals in a population, rather than the uncertainty associated with the prediction of a single event. Under such circumstances, the uncertainty is associated with the distribution used to generalize the data and draw inferences about the population as a whole. The end product of ParamFit is an Excel function containing a list of plausible alternative models which may be used to draw an inference in a two-dimensional Monte-Carlo model. It was written in Excel Visual Basic for Applications and requires Excel 5.0 or later versions and the Toxfunct add-in.

Models

There are ten distributional models that may be employed for the purpose of describing the data and drawing inferences. Any models that are checked will be fit to the data. You may select only one model, all the models, or any subset. The following distributions are supported by ParamFit:

Beta
Cauchy
Exponential
Gamma
Logistic

Lognormal
Normal
Rectangular (Uniform)
Triangular
Weibull

Model Weighting Criteria

The frequency of use of each model is allocated according to it relative model weight which is calculated as follows:
Model Weight = (((1 + n / Pn) ^ O) * ((1 - gof) ^ H)
where
n = number of observations. This value reflects the number of data points to which the curve is fit. Values below the limit of detection (i.e. text values) are not counted for this purpose.

* = Multiplication symbol.

Pn = Number of Model Parameters. In general, this refers to the number of parameters which are adjusted to fit the curve. However, the minimum values for the beta, linear, and triangular models would fit equally well if they are not truncated at a minimum value; that is, two points describe a line which could be represented as a single parameter (a slope).

gof = Goodness-of-Fit. ParamFit uses a least residual squares for the predicted percentiles as an optimization criteria. The ratio of the sum of residual squares to the sum of total squares for the predicted percentile is used as a goodness-of-fit statistic. This criteria emphasizes fit in the middle of the distribution, so that outliers have less impact on the shape of the distribution, other methods such as the "likelihood ratio" rate residual deviations in predicted distribution values.

O = The Parameter penalty, an arbitrary constant named after William of Ockam. Increasing this number increases the penalty for using an extra parameter, which influences the extent to which models are penalized for using an extra parameter The maximum value is 10. Setting this value to 0 nulifies the parameter penalty.

H = The Association factor, an arbitrary constant named after David Hume. This value can be modified to increase or decrease the reward for providing a better fit. The minimum value is 0, in which case the models are weighted without regard to how well they fit the data. Increasing this value places greater emphasis on model fit.

The specific optimization criteria for *the L. monocytogenes* concentration were:

$$\text{Gof} = \Sigma\ (\text{predicted} - \text{Observed})^2 * n * \text{concentration}^{0.25}$$

Where the parameters for the goodness of fit were Predicted and Observed are the cumulative percentiles for a given concentration of *L. monocytogenes*, n is the number of samples in the report, concentration is in cfu/g.

The model weight for the *L. monocytogenes* concentration = $1 / (pN * Gof^2)$.
Where pN is the number of adjustable parameters in the distribution being fitted.

B. MC2D

A routine for running a two-dimensional Monte-Carlo simulation in Excel. This is a technique that allows distributional components of a model representing either population frequency or uncertainty to be integrated separately. Written in Excel Visual Basic for Applications, it requires Excel 5.0 or later.

2D Monte-Carlo

Distributions and Monte-Carlo simulations may be used for two different purposes.

Variability

Variability is real variation in the individual members of a population or system with which a decision-maker is concerned. It cannot be eliminated by improved measurement technique. It is information the decision-maker needs. It answers the question being asked. A distribution describing variability describes the frequency of occurrence.

The distinction between variability and uncertainty is in some circumstances contextual, and depends on the question which is being answered. Variability which is present in the experiment that is not also present in the real world circumstances with which the decision-maker is concerned is a source of uncertainty. Uncertainty reflects imperfections in our knowledge about what is real. It can be reduced by improved technique. Although, the decision-maker should want to know the extent of the uncertainty associated with a calculation, he/she would prefer not to have it. A distribution describing uncertainty describes the likelihood or expectation of occurrence. There is often very little basis for segregating true variability from experimental variability, where the former is expected to be reproduced in the problem at hand, while the latter is not. The extent of the variability is quite often itself a source of uncertainty.

Adaptation of a Monte-Carlo simulation process to provide for separate accounting of both variability and uncertainty requires modification of both the front and back ends of the procedure. The descriptive statistics used to describe the variance for each of the data sets must have separate distributions for each source. The output from the iteration collection procedure must have two dimensions: one for variability, and one for uncertainty.

The technique known as two-dimensional Monte-Carlo is simply a simulation of simulations, in which one simulation is nested inside the other. The two-dimensional collection routine proceeds by collecting the results of a specified number of uncertainty iterations, each of which consists of a specified number of population iterations. Each of the two-dimensional functions has one or more random elements which are identified as either uncertainty or variability terms. The random terms identified as arising as a result of variability are varied after each iteration, while those identified as uncertainty terms are reset only at the start of each uncertainty iteration (*i. e.,* at the conclusion of an entire population simulation). This procedure is very calculation intensive.

Running a Monte-Carlo simulation where variability and uncertainty are distinguished allows model selection to be included as a source of uncertainty. In order to simulate model uncertainty, a probability tree may be used which distributes the use of two or more models as a source of uncertainty. Which model is used for a given uncertainty iteration (an entire population simulation) can vary randomly. The frequency of use may be varied by how well the model fits. This will ensure that the uncertainty contributed by model selection is reflected in the final analysis. Monte-Carlo is not a cure for not having data, nor does it require any more data than would otherwise be needed. It is simply a better way of a) retaining information regarding variability in an analysis, and b) retaining quantitative descriptions of the degree of uncertainty. If this is not done, the end result will appear less variable and more certain than it should.

Running MC2D

Before you run a two-dimensional Monte-Carlo simulation using MC2D, you must specify the number of iterations and identify the output cells. The number of iterations and the output cells are specified with the dialog opened by the MC2D\SETTINGS command. The size of the simulation is restricted by available memory. In order to conserve both memory and disk storage space, MC2D stores single precision numbers, which should be more than adequate for most purposes. A single-precision number requires 4 bytes of storage space. Consequently, the total size of the simulation may be calculated as follows:

bytes = 4 * Uncertainty Iterations * Variability Iterations * # of Output Cells

The total number of iterations will be the product of the number of variability iterations and the number of uncertainty iterations. The number of iterations cannot be changed once a simulation has been started. If another simulation has been run or loaded, it will be discarded (after prompting for permission). This feature allows the Iteration command to be used to reset the simulation after one has been run.

Output Range

The cells from the worksheet model from which values are collected after each iteration are specified using the OUTPUT command on the MC2D menu. The number of output cells cannot exceed 10. The output cells cannot be changed once a simulation has been started. In addition, the simulation program will not keep track of the output cell position. If the insertion or deletion of cells results in a change in the output cell(s), the Output command must be executed again to change the reference.

Reduce

If this box is checked, the population distributions will be reduced to 101 values (the minimum, maximum, and the intervening 99 percentiles). This will reduce the amount of space required for storage and the amount of time required for all subsequent calculations. However, some precision will be lost. If you have enough memory to store the whole simulation, it is recommended that this option not be used.

Autosave

If this box is checked, the simulation will be automatically saved at the end of intervals corresponding to the number of uncertainty iterations specified in the dialog.

Running the Simulation

The simulation may be started or resumed by selecting the RUN command on the MC2D menu. Memory for new simulations is allocated at this point. You may be notified if there is insufficient storage space for the simulation. The simulation will continue until it is either paused or the specified number of iterations have been completed. Simulation progress is displayed in the message bar along the bottom of the Excel window.

Saving a Simulation

Whether or not it has been completed, the current simulation may be saved using the SAVE command on the MC2D menu. The "mc2" extension is suggested as an identifier for MC2D data files. Both a header describing the simulation and the total number of iterations are stored in these files. If the model worksheet has not yet been saved, you will be prompted to do so. You must close MC2D ("EXIT") to recover the memory used by the simulation.

Loading a Simulation

A previously saved simulation may be loaded using the LOAD command on the MC2D menu. If the simulation has not been completed, MC2D will attempt to restore the simulation by opening or activating the model worksheet. The simulation may then be restarted by selecting RUN. If MC2D cannot locate the worksheet (it may have been renamed or moved), you may activate it yourself and proceed with the simulation.

Appendix 7

Listeria Contamination of Food By Study Date

Appendix 7 Table 1. Total Number of Samples and Percent Contaminated with *Listeria monocytogenes* by Food Category and Date of Study Used in this Risk Assessment.

Food Category	1993 and earlier study samples		Post-1993 study samples	
	Total	% Positive	Total	% Positive
SEAFOOD				
Smoked Seafood	2,433	12.1	1,189	21.5
Raw Seafood	2545	5.9	11,066[a]	7.4
Preserved Fish	811	7.2	503	15.1
Cooked RTE Crustaceans	178	10.1	3,461	2.5
PRODUCE				
Vegetables	2,302	7.5	1,089[a]	8.4
Fruits	340	7.4	185[a]	16.8
DAIRY				
Soft Mold-Ripened and Blue-Veined Cheese	1,334	6.6	429	3.0
Goat, Sheep, and Feta Cheese	752	7.7	79	0
Fresh Soft Cheese[b]	148[b]	12.8[b]	49[b]	30.6[c]
Heat-Treated Natural Cheeses and Processed Cheese	577	0.7[c]	89[c]	4.5
Aged Cheese	3,163	2.1	203[a]	0
Pasteurized Fluid Milk	3,146	1.0	6367	0.1
Unpasteurized Fluid Milk	9,962	4.3	3,064	4.6
Ice Cream and Frozen Dairy Products	1,536	2.0	22,794	0.6
Miscellaneous Dairy Products	756	1.5	587	0.7
MEAT				
Frankfurters	150	27.3	1,788	5.9
Dry/Semi-Dry Fermented Sausages	1706	5.9	821	12.8
Deli meats[c]	240	10.0	10805	2.7[c]
Pâté and Meat Spreads	769	19.9	4,260	3.1
COMBINATION FOODS				
Deli Salads	800	8.1	2,318	10.5

[a] Includes data from Heinitz (1999) that spans years 1990 to 1998.

[b] Modeling includes soft ripened cheese made from unpasteurized fluid milk data used as surrogate.

[c] Includes one study that used a <20 cfu/g detection limit. This value was considered to approximate the presence/absence detection limit of 0.04 cfu/g.

Appendix 8

Growth of *Listeria monocytogenes* in Foods

Appendix 8 Table 1: Growth Rate of *Listeria monocytogenes* in Food Categories Considered for this Risk Assessment Growth Product

Food Category Reference	Food	Literature Values		EGR^c at 5 °C ($\log_{10}$ cfu/day)	Maximum population ($\log_{10}$ cfu/g)
		Temperature	Growth Rate ^{a,b}		
SEAFOOD					
Smoked Seafood					
Duffes *et al*., 1999	cold-smoked salmon	4 °C 8 °C 4 °C 8 °C	2.1 logs in 28 days 5.4 logs in 21 days 2.0 logs in 21 days 4.6 logs in 14 days	0.107 0.116 0.136 0.149	> 5 8.1 5 8
Jemmi and Keusch, 1992	hot-smoked trout	4 °C 8 to 10 °C	0.5 logs in 20 days 6.5 logs in 20 days	0.035 0.120	— 8
Hudson and Mott, 1993b	cold-smoked salmon	5 °C 10 °C	4 logs in 650 hours 4-4.5 logs in 125 hours	0.148 0.249	8 – 8.5 8 – 8.5
Szabo and Cahill, 1999	Smoked salmon	4 °C 10 °C	3.9 logs in 28 days 2.7-4.3 logs in 9 days	0.198 0.119	6.3 7.6
Dillon and Patel, 1993	cold-smoked cod	4 °C	2.8 logs in 21 days	0.190	> 5
Guyer and Jemmi, 1991	Smoked salmon (26 to 30 °C)	4 °C 10 °C	1.0-1.5 logs in 10 days 3-3.5 logs in 10 days	0.177 0.099	— 6.8 - 7.5
Pelroy *et al*., 1994b	cold-smoked salmon	5 °C 5 °C 10 °C 10 °C	2.5-5 logs in 40 days 2 logs in 40 days 4.5 to 7 logs in 10 days 5 logs in 11 days	0.092 0.050 0.249 0.139	— — 6 - 8 7 to 8
Pelroy *et al*., 1994a	cold-smoked salmon	5 °C 10 °C	4 logs in 50 days 4.5 logs in 15 days	0.080 0.092	> 5 6.5
Peterson *et al*., 1993	cold-smoked salmon	5 °C 5 °C 10 °C 10 °C 10 °C	3 logs in 20 days 2.5 logs in 20 days 4 logs in 7 days 3.7 logs in 7 days 6 logs in 20 days	0.150 0.125 0.175 0.162 0.092	4 to 6 4 6 to 8 7 to 8 7
Nilsson *et al*., 1997	cold-smoked salmon	5 °C	5 logs in 9 days	0.556	8
Raw Seafood					
Fernandes *et al*., 1998	fresh trout catfish	4 °C 4 °C	1 logs in 15 days 2 logs in 15 days	0.100 0.185	6 7
Lovett *et al*., 1990	raw shrimp, crab, surimi and whitefish	7 °C	GT in 12 hours	0.342	8
Kaysner *et al*., 1990	raw oysters	4 °C	No growth in 21 days	0.000	—
Leung *et al*., 1992	catfish	4 °C	1-1.5 logs in 12 days	0.133	—
Shineman and Harrison, 1994	raw shrimp and fin fish	ice chest	No growth [Decrease 1 log in 21 days]	—	[Not used in risk assessment model

[a] logs = Log_{10} cfu/g
[b] GT = Generation Time
[c] EGR = Exponential Growth Rate

Food Category Reference	Food	Literature Values		EGR[c] at 5 °C (log$_{10}$ cfu/day)	Maximum population (log$_{10}$ cfu/g)
		Temperature	Growth Rate [a,b]		
Raw Seafood (Cont'd)					
Harrison *et al*., 1991	raw shrimp and fin fish	ice chest	No growth [Decrease 0.5 log in 14 days]	—	[Not used in Risk Assessment model]
Preserved Fish					
			No growth		
Cooked Ready-to-Eat Crustaceans					
Rawles *et al*., 1995	pasteurized crab	5 °C	GT in 21.8 hours	0.343	>8 (7 logs increase)
Farber, 1991b	cooked lobster, shrimp, crab and smoked fish	4 °C	2-3 logs in 7 days	0.508	—
Buchanan and Klawitter, 1992	pasteurized crabmeat	5 °C	3 logs in 10 days	0.300	6
PRODUCE					
Vegetables					
Steinbrugge *et al*., 1988	lettuce, whole, ready to serve	5 °C	0.00 to 0.3 logs in 7 days	0.043	6.49
		12 °C	0.00 to 2.03 logs in 7 days	0.004	6.85
	lettuce, whole, ready to serve, sealed	25 °C	0.00 to 0.31 logs in 7 days	0.002	5.85
	lettuce, whole, ready to serve, open	25 °C	0.00 to 0.35 logs in 7 days	0.002	6.08
Beuchat and Brackett, 1990b	lettuce, shredded	5 °C	0.00 to 0.1 logs in 15 days	0.007	5.0-5.5
	lettuce, shredded	10 °C	1.5-2.0 logs in 3 days	0.204	6.5-7.0
	lettuce, whole	10 °C	1.0 logs in 15 days	—	7.0-7.5
Carlin and Nguyen, 1994	lettuce, butterhead	10 °C	1.5 logs in 7 days	0.065	6
Carlin and Nguyen, 1994	lettuce, lamb's	10 °C	1.0 logs decrease in 7 days	-0.044	—
Carlin *et al*., 1996	endive, broad leaved	10 °C	1.0 logs in 7 days	0.044	5.5
Carlin and Nguyen, 1994	endive, broad leaved	10 °C	1.5 logs in 7 days	0.065	5
Carlin and Nguyen, 1994	endive, curly-leaved	10 °C	0.5 logs in 7 days	0.022	5
Beuchat and Brackett, 1991	tomatoes	10 °C	no growth (death in chopped tomatoes)	0.00	—
		21 °C	Growth		[Not used in risk assessment model]

[a]Logs = Log$_{10}$ cfu/g
[b]GT = Generation Time
[c]EGR = Exponential Growth Rate

Food Category Reference	**Food**	**Literature Values**		**EGR^c at 5 °C (log$_{10}$ cfu/day)**	**Maximum population (log$_{10}$ cfu/g)**
		Temperature	**Growth Rate ^{a,b}**		
Vegetables (Cont'd)					
Beuchat and Brackett, 1990a	carrots, whole and shredded	5 °C 15 °C	no growth up to 7 days no growth up to 7 days	0.00 0.00	spoil @ 7 days spoil @ < 7 days
Beuchat *et al*., 1986	cabbage, raw, shreds	5 °C	4 logs in 10 days	0.400	8
Berrang *et al*., 1989	asparagus	4 °C 15 °C	0.5-1.0 logs in 14-21 days 2.0 logs in 2 days	0.059 0.146	5.8 spoils 14-21 days 7.5, spoils 4-6 days
Berrang *et al*., 1989	broccoli	4 °C 15 °C	0.25-0.5 logs in 14-21 days 3.0 logs in 4 days	0.059 0.109	4.0 spoils 14-21 days 8.5 spoils 6-10
Berrang *et al*., 1989	cauliflower	4 °C 15 °C	≤ 0.25 logs in 14-21 days 3.0 logs in 4 days	0.020 0.109	3.5 spoils 14-21 days 6.5 spoils 6-8 days
Sizmur and Walker, 1988	salads, mixed , prepacked including fruits/nuts	4 °C	0.30 logs in 4 days	0.106	—
Fruits					
Parish and Higgins, 1989	orange, serum (juice)	4 °C	pH 5.0, 1.0 logs in 35 days	0.041	7.5
<u>DAIRY PRODUCTS</u>					
Soft, Mold Ripened and Blue-Veined Cheeses					
Ryser and Marth, 1987b	Camembert	6 °C ripening	4 logs in 45 days	0.066	6 to 8 3 to 5 on surface
Farber *et al*., 1987	Camembert	4 °C	Indefinite Survival	0.000	4 to 5
Back *et al*., 1993	Camembert	3 °C 6 °C 10 °C	0.9 logs in 10 days 1.5 log in 15 days 2.4 log in 15 days	0.197 0.074 0.049	5 5.4 7
Papageorgiou and Marth, 1989a	Blue cheese	5 °C	Decreased during storage, 3 logs in 56 days	0.000	—
Sulzer and Busse, 1993	Camembert	14 °C	4.5 logs in 34 days	0.022	7 (*L. innocua* surrogate)
	Camembert (surface growth)	7 °C 4 °C	— —	— —	6 4
Goat, Sheep, and Feta Cheeses					
Papageorgiou and Marth, 1989b	Feta	4 °C	survival > 90 days [Scott A 1.28 logs decrease, 3.07 logs in 90 days]	0	—
Sarumehmetoglu and Kaymaz, 1994	Turkish white Brined cheese	refrigerated	<2 logs decrease 100 days	-0.015	—
Tham, 1988	goat	—	1 logs decrease in 13 wk	-0.008	—

[a] Logs = Log$_{10}$ cfu/g
[b] GT = Generation Time
[c] EGR = Exponential Growth Rate

Food Category Reference	**Food**	**Literature Values**		**EGR[c] at 5 °C (log_{10} cfu/day)**	**Maximum population (log_{10} cfu/g)**
		Temperature	**Growth Rate [a,b]**		
Fresh Soft Cheeses					
Glass *et al*., 1995	queso blanco	4 °C	1.4 logs in 14 days	0.142	7.9 [Not used in risk assessment model]
		20 °C	—	—	
Heat-Treated Natural Cheeses and Processed Cheese					
Genigeorgis *et al*., 1991	cottage cheese	8 °C	0.59 logs in 18 days	0.015	—
	(multiple brands)		1.87 decrease in 36 days	-0.024	—
			0.42 logs in 24 days	0.007	—
			1.13 logs in 8 days	0.064	—
			1.87 decrease in 8 days	-0.106	—
		4 °C	0.39 logs in 24 days	0.023	—
			0.34 logs in 24 days	0.020	—
			0.41 logs in 16 days	0.036	—
			0.94 logs in 36 days	0.037	—
			1.87 logs decrease in 8 days	-0.333	—
	teleme cheese	8 °C	2.2 logs in 36 days	0.028	—
		4 °C	0.42 logs decrease in 36 days	-0.017	—
	ricotta	8 °C	2.11 logs in 8 days	0.120	—
	(3 company brands)		1.75 logs in 6 days	0.132	—
			1.88 logs in 8 days	0.106	—
		4 °C	1.53 logs in 30 days	0.072	—
			3.58 logs in 36 days	0.141	—
			1.97 logs in 22 days	0.127	—
	cream cheese	8 °C	2.0 logs decrease in 30 days	-0.030	—
		4 °C	2.0 logs decrease in 36 days	-0.079	—
Cottin *et al*., 1990	cream cheese	4 °C	2 logs in 2 days	1.423	3
Papageorgiou *et al*., 1996	ricotta (whey cheese)	5 °C	16.2 – 20.2 hr in GT	0.397	7 to 8
		12 °C	5.1 – 5.8 hr in GT	0.292	—
Chen and Hotchkiss, 1993	cottage cheese	4 °C	2.0 logs in 40 days	0.071	7.5
		7 °C	2.4 logs in 10 days	0.137	7.4
Fedio *et al*., 1994	cottage cheese	5 °C	2 logs in 22 days	0.091	6.0
El-Shenawy and Marth, 1990	cottage cheese	refrigerated	0.5 to 1.5 logs decrease in 1 to 5 wk	—	—
		6 °C	assume 1 log in 21 days	-0.035	—
Stecchini *et al*., 1995	mozzarella	5 °C	4 logs in 21 days	0.190	—
Aged Cheese					
Northolt *et al*., 1988	gouda	—	Survival 6 weeks	0.000	2 to 4
Yousef and Marth, 1988	colby	4 °C	1.5 logs decrease in 100 days (after 40 days)	-0.053	3.5 to 4.5
Ryser and Marth, 1987a	cheddar	13 °C	2 logs decrease in 75 to 150 days	-0.003	3.7

[a] Logs = Log_{10} cfu/g
[b] GT = Generation Time
[c] EGR = Exponential Growth Rate

Food Category Reference	**Food**	**Literature Values**		**EGR^c at 5 °C (log$_{10}$ cfu/day)**	**Maximum population (log$_{10}$ cfu/g)**
		Temperature	**Growth Rate ^{a,b}**		
Aged Cheese (Cont'd)					
Buazzi *et al*., 1992	swiss	7 °C	4 logs decrease in 10 days (complete inactivation 66-80 days ripening at 24 °C)	-0.228	—
Bachmann and Spahr, 1995	emmenthaler, tilster	—	no survival after 24 hours (initial level was 10^4 cfu/g)	—	—
Kaufmann, 1990	emmenthaler, gruyere	—	no survival after 24 hours (initial level was 10^4 cfu/g)	—	—
Yousef and Marth, 1990	parmesan	—	no survival after aging	0.015 0.000	—
Ryser and Marth, 1989a	Brick (surface ripened)	—	can get to high number during ripening	—	—
	tilsiter, trappist, havarti, limburger	10 °C	< 1 logs in 20 wk	0.015	—
Kovincic *et al*., 1991	Trappist	—	Initial 1 log during ripening, stable 30 days, decrease for 90 days	0.000	—
Fluid Milk, Pasteurized and Unpasteurized					
Northolt *et al*, 1988	unpasteurized milk	5 °C 7 °C	GT 3.5 in days GT 1.0 in days	0.085 0.173	— —
Northolt *et al*, 1988	pasteurized milk	4 °C 7 °C	2 logs in 7 days 2 logs in 3 days	0.407 0.380	— —
Farber *et al*., 1990	unpasteurized fluid milk	4 °C 10 °C 15 °C	GT in 25.3 hours GT in 10.8 hours GT in 7.4 hours	0.404 0.204 0.142	7.1 7.1 7.1
Rajkowski *et al*., 1994	uht milk	12 °C	GT in 4.7 hours	0.337	—
Rosenow and Marth, 1987	skim, whole, chocolate milk	4 °C 8 °C	3.3 logs in 18 days 4 logs in 8 days	0.261 0.227	7 (chocolate 8.5) 7.5
Ice Cream & Frozen Dairy Products					
Berrang *et al*., 1988	ice cream	—	No growth	—	—
Dean and Zottola, 1996	soft serve	—	No growth	—	—
Miscellaneous Dairy Products					
Rosenow and Marth, 1987	cream	4 °C 8 °C	3.3 logs in 18 days 4 logs in 8 days	0.261 0.227	7 8.0
Farrag *et al*., 1990	sweetened condensed milk	7 °C	decrease 1.2 logs in 42 days	-0.016	—
	evaporated milk	7 °C	4 logs in 14 days	0.163	—
Olsen *et al*., 1988	butter	4 to 6 °C 13 °C	1.9 logs in 49 days 2.7 logs in 42 days	0.039 0.012	5.5 6

[a] Logs = Log$_{10}$ cfu/g
[b] GT = Generation Time
[c] EGR = Exponential Growth Rate

Food Category Reference	Food	Literature Values		EGR[c] at 5 °C	Maximum population
		Temperature	Growth Rate [a,b]	(log$_{10}$ cfu/day)	(log$_{10}$ cfu/g)
Miscellaneous Dairy Products (Cont'd)					
Schaack and Marth, 1988	buttermilk	4 °C	decrease, survives 2.5-13 wk	-0.02	—
	yogurt	4 °C	decrease, survived 4-12 days (~1 log decline detectable)	-0.18	—
Choi *et al*., 1988	yogurt	4 °C	survives 21-24 days, most drop in first 8-12 days (~2 log decline detectable)	-0.12	—
Siragusa and Johnson, 1988b	buttermilk	4 °C	survives 18-26 days	-0.12	—
	yogurt	5 °C	low level survived < 3 days	—	—
			high level survived 9 days [2 logs drop in 3-6 days]	-0.40	—
<u>MEATS</u>					
Frankfurters					
Glass and Doyle, 1989	frankfurters	4.4 °C	2.3 logs in 6 weeks	0.064	—
McKellar *et al*., 1994.	frankfurters	5 °C	3.5 logs in 21 days	0.168	—
McKellar *et al*., 1994.	poultry wieners	5 °C	3.5 logs in 21 days	0.090	—
Wederquist *et al*., 1994	turkey	4 °C	7.0 logs in 55 days	0.181	—
Dry/Semi-Dry Fermented Sausages					
Farber and Peterkin, 1999	various	—	No growth	—	—
Deli Meats					
Glass and Doyle, 1989	bologna	4.4 °C	1 to 2 logs in 14 days	0.131	—
Grau and Vanderline, 1992	corned beef	4.8 °C	0.13	0.130	—
Grau and Vanderline, 1992	vacuum packed ham	5 °C	0.30	0.300	—
Glass and Doyle, 1989	cooked ham	4.4 °C	2 to 3 logs in 28 days	0.131	—
Beumer *et al*., 1996	cooked ham	7 °C	6 logs in 35 days	0.098	—
Grant *et al*., 1993	roast beef	5 °C 10 °C	5 logs in 15 days 5 logs in 6 days	0.333 0.254	7.9 8.7
Glass and Doyle, 1989	chicken, sliced, vacuum packed	4.4 °C 4.4 °C	4.15 logs in 14 days 5.90 logs in 14 days	0.364 0.517	<8.46@ spoilage <8.34 @ spoilage
Siragusa and Johnson, 1988a	chicken, homogenate	4.0 °C	5.2 logs in 20 days	0.370	7.9
Siragusa and Johnson, 1988a	chicken fillets, breaded	5.0 °C	0.9 logs in 6 days	0.150	—

[a] Logs = Log$_{10}$ cfu/g
[b] GT = Generation Time
[c] EGR = Exponential Growth Rate

Food Category Reference	**Food**	**Literature Values**		**EGR[c] at 5 °C (log$_{10}$ cfu/day)**	**Maximum population (log$_{10}$ cfu/g)**
		Temperature	**Growth Rate [a,b]**		
Deli Meats (Cont'd)					
Glass and Doyle, 1989	turkey, sliced	4.4 °C	2.0 logs in 14 days	0.175	6.15 pre-spoilage
		4.4 °C	3.11 logs in 28 days	0.136	3.73 pre-spoilage
		4.4 °C	3.08 logs in 14 days	0.270	
Glass and Doyle, 1989	turkey, sliced	4.4 °C	3.83 logs in 14 days	0.336	<8.28 @ spoilage
	vacuum packed	4.4 °C	5.09 logs in 14 days	0.446	<8.32 @ spoilage
Ingham and Tautorus, 1991	turkey loaf, cooked, uncured, vacuum	3 °C	0.09 logs in 12 days	0.016	—
Pâté and Meat Spreads					
Farber *et al*., 1995	pâté	5 °C	0.361 log in 1 day	0.361	6 to 7
Hudson and Mott, 1993a	pâté	4 °C	4 logs in 680 hours	0.143	—
COMBINATION FOODS					
Deli Salads					
			No data found		

[a] Logs = Log$_{10}$ cfu/g
[b] GT = Generation Time
[c] EGR = Exponential Growth Rate

Appendix 9
Additional Risk Characterization Information

Appendix 9. Table 1. Predicated Number of Cases of Listeriosis per Annum for each Food Category and Population

Food Category	Predicted Number of Cases of Listeriosis per Annum								
	Perinatal Percentiles			Elderly Percentiles			Intermediate-Age Percentiles		
	Median	5th	95th	Median	5th	95th	Median	5th	95th
SEAFOOD									
Smoked Seafood	6.2	0.8	63.4	18.5	0.2	1,105.2	8.6	0.0	1,295.0
Raw Seafood	0.1	0.0	1.5	0.0	0.0	0.3	0.1	0.0	32.7
Preserved Fish	0.7	0.0	7.5	1.8	0.0	138.1	0.6	0.0	154.8
Cooked Ready-to-Eat Crustaceans	3.8	0.4	37.1	8.4	0.0	498.6	5.6	0.0	878.9
PRODUCE									
Vegetables	3.2	0.0	495.5	7.4	0.0	3,809.1	3.9	0.0	3,006.6
Fruits	0.5	0.0	45.1	1.3	0.0	484.9	0.4	0.0	370.2
DAIRY									
Soft Mold-Ripened and Blue-Veined Cheese	0.4	0.0	9.5	0.8	0.0	96.0	0.5	0.0	125.7
Goat, Sheep, and Feta Cheese	0.0	0.0	1.1	0.0	0.0	10.0	0.0	0.0	8.1
Fresh Soft Cheeses	7.0	1.1	50.0	4.3	0.1	188.3	7.5	0.0	964.3
Heat-Treated Natural Cheeses and Processed Cheese	3.7	0.4	31.1	7.4	0.1	399.6	5.1	0.0	776.8
Aged Cheeses	0.0	0.0	69.1	0.0	0.0	305.4	0.0	0.0	348.1
Pasteurized Fluid Milk	67.0	12.5	276.7	224.2	7.9	4,082.7	119.7	1.0	6,748.9
Unpasteurized Fluid Milk	0.3	0.0	2.2	0.75	0.0	27.8	0.4	0.0	43.9
Ice Cream/Frozen Dairy Products	0.0	0.0	198.5	0.0	0.0	1,083.6	0.0	0.0	676.6
Miscellaneous Dairy Products	13.1	1.9	70.1	41.0	0.9	1,198.5	19.7	0.0	1,687.3
MEATS									
Frankfurters	22.8	2.4	201.5	32.0	0.3	1,552.0	34.9	0.0	4,570.3
Dry/Semi-Dry Fermented Sausages	1.2	0.0	30.8	2.1	0.0	222.7	1.2	0.0	377.9
Deli Meats	325.5	41.3	2,467.4	650.3	8.6	32,091.9	470.6	0.5	63,701.5
Pâté and Meat Spreads	4.3	0.7	25.7	12.3	0.2	444.2	6.4	0.0	682.5
COMBINATION FOOD									
Deli Salads	41.1	6.8	356.8	142.2	3.4	5,923.7	199.4	0.7	22,302.4

Appendix 9. Table 2a: Certainty For a Specified Predicted Listeriosis per Serving by Food Category¾ Intermediate Age

Note: The Intermediate Age includes susceptible populations not captured as elderly or Perinatal, such as cancer, AIDS, and transplant patients, from whom there are insufficient data to consider as a separate population.

Servings per 1 case of Listeriosis	Rate of Listeriosis	Smoked Seafood	Raw Seafood	Preserved Fish	Cooked RTE Crustaceans	Vegetables	Fruits	Soft Mold-Ripened and Blue-Veined	Goat, Sheep, and Feta Cheese	Fresh Soft Cheeses	Heat-Treated Natural and Processed Cheeses	Aged Cheeses	Fluid Milk - Pasteurized	Fluid Milk - Unpasteurized	Ice Cream and Frozen Dairy Products	Miscellaneous Dairy Products	Frankfurters	Dry/Semi-Dry Ferm Sausages	Deli Meats	Pâté and Meat Spreads	Deli Salads
10^{12}	1.0×10^{-12}	0.98	0.92	0.92	0.97	0.80	0.67	0.95	0.78	0.99	0.93	0.44	0.98	0.95	0.41	0.96	0.96	0.90	0.98	0.99	0.98
10^{11}	1.0×10^{-11}	0.97	0.86	0.89	0.96	0.66	0.50	0.93	0.64	0.98	0.87	0.37	0.96	0.90	0.37	0.92	0.94	0.84	0.96	0.98	0.97
10^{10}	1.0×10^{-10}	0.94	0.73	0.80	0.92	0.38	0.31	0.85	0.45	0.96	0.70	0.23	0.89	0.77	0.31	0.82	0.89	0.70	0.94	0.96	0.94
10^{9}	1.0×10^{-9}	0.89	0.42	0.67	0.82	0.15	0.14	0.64	0.21	0.91	0.31	0.09	0.60	0.51	0.26	0.47	0.75	0.48	0.87	0.92	0.86
10^{8}	1.0×10^{-8}	0.76	0.16	0.47	0.53	0.10	0.05	0.26	0.08	0.78	0.13	0.06	0.19	0.20	0.13	0.15	0.40	0.24	0.67	0.80	0.56
10^{7}	1.0×10^{-7}	0.38	0.08	0.14	0.18	0.01	0.00	0.13	0.02	0.40	0.01	0.01	0.05	0.06	0.05	0.03	0.14	0.09	0.26	0.42	0.18
10^{6}	1.0×10^{-6}	0.14	0.00	0.08	0.09	0.00	0.00	0.02	0.00	0.14	0.00	0.00	0.00	0.00	0.02	0.00	0.04	0.03	0.13	0.14	0.09
10^{5}	1.0×10^{-5}	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
10^{4}	1.0×10^{-4}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NOTE: All values are cumulative probabilities that give the likelihood that the listeriosis rate will be less than or equal to the indicated rate of listeriosis value (i.e. 10^{-12} to 10^{-4}).

Example: Using smoked seafood, the values in the table can be interpreted to predict that for the Intermediate Age, there is an 98% probability that smoked seafood would be responsible for causing one case for every one trillion servings consumed, an 97% probability for one case for every one hundred billion servings consumed, a 94% probability of being responsible for one case for every ten billion servings, a 89% probability of being responsible for one case for every one billion servings, a 76% probability of being responsible for one case for every one hundred million servings, a 38% probability of being responsible for one case for every ten million servings, and a 14% probability of being responsible for one case for every one million servings. This manner of presentation provides estimates of both the risk associated with the various food groups and the uncertainty associated with those predictions.

Appendix 9. Table 2b: Certainty For a Specified Predicted Listeriosis per Serving by Food Category ¾ Elderly Population

Servings per 1 case of Listeriosis	Rate of Listeriosis per Serving	Smoked Seafood	Raw Seafood	Preserved Fish	Cooked RTE Crustaceans	Vegetables	Fruits	Soft Mold-Ripened and Blue-Veined Cheese	Goat, Sheep, and Feta Cheese	Fresh Soft Cheeses	Heat-Treated Natural and Processed Cheeses	Aged Cheeses	Fluid Milk - Pasteurized	Fluid Milk - Unpasteurized	Ice Cream and Frozen Dairy Products	Miscellaneous Dairy Products	Frankfurters	Dry/Semi-Dry Ferm Sausages	Deli Meats	Pâté and Meat Spreads	Deli Salads
10^{12}	1.0×10^{-12}	1.00	0.97	0.95	1.00	0.84	0.72	0.99	0.82	1.00	0.98	0.48	1.00	0.98	0.43	0.99	1.00	0.94	1.00	1.00	1.00
10^{11}	1.0×10^{-11}	1.00	0.93	0.93	0.99	0.73	0.56	0.97	0.70	1.00	0.94	0.40	0.99	0.95	0.38	0.97	0.98	0.89	1.00	1.00	1.00
10^{10}	1.0×10^{-10}	0.98	0.82	0.86	0.97	0.45	0.37	0.92	0.51	1.00	0.81	0.26	0.95	0.85	0.35	0.91	0.95	0.76	0.98	1.00	0.98
10^{9}	1.0×10^{-9}	0.95	0.50	0.73	0.91	0.16	0.16	0.76	0.26	0.97	0.39	0.10	0.74	0.61	0.30	0.59	0.86	0.56	0.94	0.97	0.92
10^{8}	1.0×10^{-8}	0.86	0.18	0.56	0.64	0.11	0.04	0.33	0.09	0.91	0.12	0.06	0.24	0.25	0.17	0.17	0.51	0.29	0.78	0.89	0.63
10^{7}	1.0×10^{-7}	0.48	0.07	0.19	0.21	0.01	0.00	0.13	0.02	0.61	0.00	0.02	0.01	0.03	0.05	0.01	0.16	0.08	0.34	0.54	0.19
10^{6}	1.0×10^{-6}	0.14	0.00	0.07	0.06	0.00	0.00	0.01	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.12	0.15	0.03
10^{5}	1.0×10^{-5}	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10^{4}	1.0×10^{-4}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NOTE: All values are cumulative probabilities that give the likelihood that the case rate attributable to listeriosis will be less than or equal to the indicated rate of listeriosis value (i.e. 10^{-12} to 10^{-4}).

Example: Using smoked seafood, the values in the table can be interpreted to predict that, for the elderly, there is a 100% probability that smoked seafood would be responsible for causing one case for every one trillion servings consumed, a 100% probability for one case for every one hundred billion servings consumed, a 98% probability of being responsible for one case for every ten billion servings, a 95% probability of being responsible for one case for every one billion servings, a 86% probability of being responsible for one case for every one hundred million servings, a 48% probability of being responsible for one case for every ten million servings, an 14% probability of being responsible for one case for every one million servings, and a 1% probability of being responsible for one case for every hundred thousand servings. This manner of presentation provides estimates of both the risk associated with the various food groups and the uncertainty associated with those predictions.

Appendix 9 Table 2c: Certainty For a Specified Predicted Listeriosis per Serving by Food Category ¾ Perinatal Population

Note: The Perinatal population is a susceptible population that includes fetuses and neonates. Exposure occurs most often *in utero* from contaminated food eaten by the pregnant woman.

Servings per 1 case of Listeriosis	Rate of Listeriosis per Serving	Smoked Seafood	Raw Seafood	Preserved Fish	Cooked RTE Crustaceans	Vegetables	Fruits	Soft Mold-Ripened and Blue-Veined Cheese	Goat, Sheep, and Feta Cheese	Fresh Soft Cheeses	Heat-Treated Natural and Processed Cheeses	Aged Cheeses	Fluid Milk - Pasteurized	Fluid Milk - Unpasteurized	Ice Cream and Frozen Dairy Products	Miscellaneous Dairy Products	Frankfurters	Dry/Semi-Dry Ferm Sausages	Deli Meats	Pâté and Meat Spreads	Deli Salads
10^{12}	1.0×10^{-12}	1.00	1.00	0.98	1.00	0.98	0.94	1.00	0.96	1.00	1.00	0.85	1.00	1.00	0.75	1.00	1.00	0.98	1.00	1.00	1.00
10^{11}	1.0×10^{-11}	1.00	1.00	0.98	1.00	0.97	0.91	1.00	0.93	1.00	1.00	0.71	1.00	1.00	0.66	1.00	1.00	0.97	1.00	1.00	1.00
10^{10}	1.0×10^{-10}	1.00	1.00	0.97	1.00	0.95	0.81	1.00	0.90	1.00	1.00	0.55	1.00	1.00	0.49	1.00	1.00	0.96	1.00	1.00	1.00
10^{9}	1.0×10^{-9}	1.00	1.00	0.96	1.00	0.88	0.66	1.00	0.80	1.00	1.00	0.47	1.00	1.00	0.40	1.00	1.00	0.94	1.00	1.00	1.00
10^{8}	1.0×10^{-8}	1.00	0.97	0.92	1.00	0.66	0.49	1.00	0.62	1.00	0.98	0.39	1.00	0.96	0.39	1.00	1.00	0.87	1.00	1.00	1.00
10^{7}	1.0×10^{-7}	1.00	0.77	0.81	1.00	0.23	0.26	0.96	0.39	1.00	0.66	0.16	0.97	0.79	0.35	0.88	.99	0.71	1.00	1.00	1.00
10^{6}	1.0×10^{-6}	0.99	0.28	0.73	0.91	0.13	0.03	0.58	0.12	1.00	0.09	0.06	0.33	0.36	0.27	0.21	.80	0.42	0.98	1.00	0.76
10^{5}	1.0×10^{-5}	0.79	0.03	0.35	0.34	0.00	0.00	0.13	0.00	0.91	0.00	0.01	0.00	0.00	0.05	0.00	0.20	0.08	0.60	0.85	0.12
10^{4}	1.0×10^{-4}	0.16	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.16	0.00
10^{3}	1.0×10^{-3}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NOTE: All values are cumulative probabilities that give the likelihood that the case rate attributable to listeriosis will be less than or equal to the indicated rate of listeriosis value (i.e. 10^{-12} to 10^{-5}).

Note: Based upon data collected by the California State Department of Health Services (Buchholz, pers.comm), prenatal cases numbered 1.5 times the number of neonatal cases. The cases presented in this table account for prenatal and neonatal cases.

Example: Using Smoked Seafood, the values in the table can be interpreted to predict that, for pregnant women and their fetuses and newborns, there is a 100% probability that smoked seafood would be responsible for causing one case for every one trillion servings consumed, a 100% probability for one case for every one hundred billion servings consumed, a 100% probability of being responsible for one case for every ten billion servings, a 100% probability of being responsible for one case for every one billion servings, a 100% probability of being responsible for one case for every one hundred million servings, a 100% probability of being responsible for one case for every ten million servings, a 99% probability of being responsible for one case for every one million servings, a 79% probability of being responsible for one case for every hundred thousand servings, and a 16% probability of being responsible for one case for every ten thousand servings. This manner of presentation provides estimates of both the risk associated with the various food groups and the uncertainty associated with those predictions.

Appendix 9 -Table 3a: Certainty For a Specified Predicted Rate of Listerosis per Annum by Food Category – Intermediate Age Population

Note: The Intermediate Age includes susceptible populations not captured as elderly or Perinatal, such as cancer, AIDS, and transplant patients, from whom there are insufficient data to consider as a separate population.

U.S. Annual Listeriosis Rate	Smoked Seafood	Raw Seafood	Preserved Fish	Cooked RTE Crustaceans	Vegetables	Fruits	Soft Mold-Ripened and Blue-Veined Cheese	Goat, Sheep, and Feta Cheese	Fresh Soft Cheeses	Heat-Treated Natural Cheeses and Processed Cheese	Aged Cheeses (semi-soft, hard, semi-hard, processed)	Pasteurized Fluid Milk	Unpasteurized Fluid Milk	Ice Cream and Frozen Dairy Products	Miscellaneous Dairy Products	Frankfurters	Dry/Semi-Dry Fermented Sausages	Deli Meats	Pâté and Meat Spreads	Deli Salads
0.01	0.95	0.78	0.79	0.95	0.86	0.74	0.88	0.51	0.96	0.94	0.45	0.99	0.86	0.41	0.97	0.95	0.86	0.98	0.96	0.99
0.10	0.91	0.51	0.66	0.90	0.79	0.60	0.74	0.28	0.92	0.89	0.38	0.97	0.68	0.37	0.94	0.93	0.73	0.97	0.92	0.97
1.00	0.81	0.20	0.44	0.76	0.66	0.43	0.38	0.10	0.81	0.76	0.24	0.95	0.37	0.32	0.87	0.87	0.53	0.94	0.79	0.94
10.00	0.47	0.11	0.13	0.39	0.38	0.23	0.14	0.04	0.45	0.38	0.10	0.87	0.12	0.27	0.62	0.70	0.28	0.89	0.42	0.88
100.00	0.15	0.00	0.08	0.14	0.15	0.09	0.07	0.00	0.14	0.14	0.06	0.54	0.01	0.15	0.22	0.31	0.11	0.75	0.14	0.63
1000.00	0.08	0.00	0.00	0.04	0.10	0.03	0.00	0.00	0.05	0.03	0.02	0.16	0.00	0.05	0.09	0.13	0.04	0.36	0.02	0.22

NOTE: All values are cumulative probabilities that give the likelihood that the listeriosis case rate will be less than or equal to the indicated value (i.e. 0.1,1,10, 100, or 1000). A case rate of 0.1 corresponds to 1 case every 10 years.

Example: Using Smoked Seafood as an example, the values in the table can be interpreted to predict that, in the Intermediate Age, there is a 91% probability that smoked seafood would be responsible for one case every 10 years, a 81% probability of 1 case per year, a 47% probability of 10 cases per year, a 15% probability of 100 cases per year and 0% probability. This manner of presentation provides estimates of both the risk associated with the various food groups and the uncertainty associated with those predictions.

Appendix 9-Table 3b: Certainty For a Specified Predicted Rate of Listerosis per Annum by Food Category¾ Elderly Population

U.S. Annual Listeriosis Rate	Smoked Seafood	Raw Seafood	Preserved Fish	Cooked RTE Crustaceans	Vegetables	Fruits	Soft Mold-Ripened and Blue Veined Cheese	Goat/Feta Cheese	Fresh Soft Cheese	Heat-Treated Natural Cheeses and Processed Cheese	Aged Cheeses (semi-soft, hard, semi-hard, processed)	Pasteurized Fluid Milk	Unpasteurized Fluid Milk	Ice Cream and Frozen Dairy Products	Misc. Dairy	Frankfurters	Sausage	Deli Meat	Pâté and Meat Spreads	Deli Salads
0.01	0.99	0.30	0.86	0.99	0.90	0.81	0.94	0.58	0.99	0.98	0.47	1.00	0.92	0.45	1.00	0.99	0.90	1.00	1.00	1.00
0.10	0.97	0.12	0.73	0.95	0.85	0.69	0.84	0.35	0.95	0.95	0.40	1.00	0.77	0.38	0.98	0.97	0.78	1.00	0.97	1.00
1.00	0.90	0.00	0.58	0.85	0.74	0.52	0.47	0.13	0.79	0.83	0.25	0.99	0.45	0.36	0.95	0.92	0.58	0.98	0.89	0.98
10.00	0.63	0.00	0.21	0.46	0.46	0.33	0.14	0.05	0.32	0.44	0.09	0.94	0.12	0.31	0.78	0.71	0.31	0.95	0.54	0.91
100.00	0.19	0.00	0.07	0.13	0.17	0.13	0.05	0.00	0.11	0.14	0.06	0.68	0.00	0.20	0.32	0.28	0.10	0.83	0.15	0.57
1000.00	0.06	0.00	0.00	0.01	0.11	0.03	0.00	0.00	0.00	0.01	0.01	0.19	0.00	0.05	0.06	0.09	0.02	0.41	0.00	0.16

NOTE: All values are cumulative probabilities that give the listeriosis case rate will be less than or equal to the indicated value (i.e. 0.1,1,10, 100, or 1000). A case rate of 0.1 corresponds to 1 case every 10 years.

Example: Using Smoked Seafood as an example, the values in the table can be interpreted to predict that, for the elderly, there is a 97% probability that smoked seafood would be responsible for one case every 10 years, a 90% probability of 1 case per year, a 63% probability of 10 cases per year, and a 19% probability of 100 cases per year. This manner of presentation provides estimates of both the risk associated with the various food groups and the uncertainty associated with those predictions.

Appendix 9-Table 3c: Certainty For a Specified Predicted Rate of Listerosis per Annum by Food Category ¾ Perinatal Population

Note: The Perinatal population is a susceptible population that includes fetuses and neonates. Exposure occurs most often *in utero* from contaminated food eaten by the pregnant woman.

U.S. Annual Listeriosis Rate	Smoked Seafood	Raw Seafood	Preserved Fish	Cooked RTE Crustaceans	Vegetables	Fruit	Soft Mold-Ripened and Blue-Veined Cheese	Goat, Sheep and Feta Cheese	Fresh Soft Cheeses	Heat-Treated Natural Cheeses and Processed Cheese	Aged Cheeses (semi-soft, hard, semi-hard, processed)	Pasteurized Fluid Milk	Unpasteurized Fluid Milk	Ice Cream and Frozen Dairy Products	Miscellaneous Dairy Products	Frankfurters	Dry/Semi-Dry Fermented Sausages	Deli Meats	Pâté and Meat Spreads	Deli Salads
0.01	1.00	0.88	0.82	1.00	0.95	0.79	0.99	0.51	1.00	1.00	0.48	1.00	0.93	0.41	1.00	1.00	0.91	1.00	1.00	1.00
0.10	1.00	0.43	0.74	1.00	0.90	0.63	0.84	0.24	1.00	0.99	0.42	1.00	0.72	0.39	1.00	1.00	0.77	1.00	1.00	1.00
1.00	0.93	0.09	0.41	0.84	0.70	0.45	0.24	0.06	0.96	0.84	0.21	1.00	0.19	0.35	0.98	.99	0.53	1.00	0.91	1.00
10.00	0.35	0.00	0.03	0.22	0.28	0.20	0.04	0.00	0.38	0.23	0.06	0.97	0.00	0.31	0.59	.74	0.22	1.00	0.23	0.90
100.00	0.01	0.00	0.00	0.00	0.13	0.01	0.00	0.00	0.00	0.00	0.03	0.33	0.00	0.09	0.02	0.15	0.01	0.83	0.00	0.24
1000.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00

NOTE: All values are cumulative probabilities that give the likelihood that the case rate attributable to listeriosis will be less than or equal to the indicated value (i.e. 0.1,1,10, 100, or 1000). A case rate of 0.1 corresponds to 1 case every 10 years.

Note: Based upon data collected by the California State Department of Health Services (Buchholz, pers.comm), prenatal cases numbered 1.5 times the number of neonatal cases. The cases presented in this table account for prenatal and neonatal cases.

Example: Using Smoked Seafood as an example, the values in the table can be interpreted to predict that, for pregnant women and their fetuses and newborns, there is a 100% probability that smoked seafood would be responsible for one case every 10 years, a 93% probability of 1 case per year, and a 35% probability of 10 cases per year. This manner of presentation provides estimates of both the risk associated with the various food groups and the uncertainty associated with those predictions.