Modelling of Exposure of New Zealand consumers to *Salmonella*

NZFSA Science Group Report

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Requests for further copies should be directed to :
New Zealand Food Safety Authority
P O Box 2835
WELLINGTON
Telephone : (04) 463 2500
Fax : (04) 463 2501

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1 Executive Summary

The New Zealand Food Safety Authority (NZFSA) is committed to the development of risk-based food safety standards for the domestic, import and export sectors using robust risk analysis methods. To this end a major evaluation has been conducted of:

- The relative likelihood of New Zealanders becoming ill from *Salmonella* transmitted via food compared with *Salmonella* being transmitted via other pathways such as direct contact with animals and overseas travel
- Changes in relative likelihood of foodborne salmonellosis that may eventuate from importation of poultry products from overseas according to specific import scenarios.

This Science Group report provides the scientific basis for identification and selection of risk management options in relation to different scenarios for imported poultry products and is presented in three parts, as follows.

1.1 Evaluation of foodborne and other pathways for exposure of New Zealanders to *Salmonella*

The scientific evaluation of foodborne and other pathways for exposure of New Zealanders to *Salmonella* demonstrates that the majority of cases (estimated at 63%) arise from foodborne exposure with domestic poultry being the dominant pathway. Some foods previously considered to be 'high risk' either make a very small contribution to the human burden (ice cream, desiccated coconut, spices) or do not register at all (peanut butter) and a significant number of cases are due to imported foods e.g. all tahini and sesame seeds are imported and 83 cases a year are attributable to these foods.

Potentially, 'antibiotic multi-resistant *Salmonella*' (AMRS) might be found contaminating almost any food but the reported rate of such infections in New Zealand is low. Sporadic AMRS infection also arises from other pathways identified in the study, especially overseas travel.

This study provides a scientific basis for ranking of risks associated with imported foods and updating regulatory controls on that basis. The relative risk model can be used to rapidly evaluate "new" importations of food types that may be contaminated with *Salmonella*.

1.2 An investigation of the effect of importing Bernard Matthew Foods Ltd. turkey meat preparations from the United Kingdom on human salmonellosis in New Zealand

The quantitative framework described above was used to estimate the burden of human salmonellosis that would likely occur in New Zealand as a result of the importation of Bernard Matthew Foods Ltd. turkey meat 'nugget-like' products from the United Kingdom. The simulation model estimated that an extra 14 cases of foodborne salmonellosis would arise on an annual basis in New Zealand consumers if consumption of turkey products in New Zealand increased by 20% and Bernard Matthew Foods Ltd. turkey meat 'nugget-like' products were the source. Against a background of the total estimated 5,700 cases (i.e. notified and not notified cases) this number has no biological or statistical significance. A conservative stochastic simulation of a proportion of these cases being due to AMRS further illustrated the extremely minor changes in disease burden that might occur.

The evaluations were carried out using model inputs from the United Kingdom, Bernard Matthew Foods Ltd. as the processor and the controls currently in place for turkey meat preparations. Therefore the scientific evaluation is specific to this scenario. However, it is unlikely that importing poultry from different processors in the UK would result in a measurable increase in the burden of salmonellosis in New Zealand (see Section 4).

The Science Group recommends that no specific regulatory controls are needed in New Zealand if Bernard Matthew Foods Ltd. turkey meat preparations are imported from the United Kingdom as there would be no measurable increase in the burden of human salmonellosis.

1.3 A risk analysis of the public health impact of human salmonellosis that could arise from the importation of poultry or turkey products from any Member State of the European Union

The objective of this analysis was to assess human salmonellosis risks that may be posed by poultry or turkey imports from European Union (EU) producers or from EU Member States. This study builds on the data and methodology presented in Sections 2 and 3 and presents a summary of scientific findings. Comparisons are made between the relative levels of contamination of poultry before heat treatment or freezing and this is taken as a surrogate for relative exposure at the time of consumption and the ensuing risks to human health. There has been agreement at the Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment (JEMRA) that this is a reasonable assumption.

Data reported by the Member States indicate there is a wide variation in prevalence for both 'ordinary' *Salmonella* and AMRS across the EU. However, in some cases the sample sizes in these reports were very small leading to large statistical uncertainty intervals. Survey methods were not reported and thus it is not possible to comment on how representative the reported figures are.

The available data indicates that the prevalence of *Salmonella* in poultry in EU Member States is not directly comparable to New Zealand. Prevalence ratios are less than 1 for Sweden, Finland, Spain and Ireland. Prevalence ratios for most other countries are less than 5. However, one Member State (Cyprus) is above 10. The prevalence of AMRS in New Zealand (2005, human isolates 2.5%, animal and environmental isolates 0%) is lower than reported from the EU (mean poultry isolates 8.5%).

Salmonella prevalence and poultry production in the Member States are often disparate. A 'production corrected' prevalence which more accurately reflects overall exposure of consumers in the EU was calculated. This figure, 4.24%, is 1.35 times a similar figure, 3.14%, calculated from slaughter plant data in New Zealand.

A stochastic model of the total (i.e. all causes including travel) human burden of salmonellosis in New Zealand was constructed and a variety of poultry import scenarios were investigated. The public health impacts were assessed in terms of officially notified numbers of human cases, AMRS cases, cases hospitalised, cases that die and cases where there would be long term disability. A gradual increase in potential risks occurs as the disparity between the level of *Salmonella* contamination of New Zealand poultry and substituted EU poultry increases. As a consequence, different EU Member States are grouped as to the likely level of foodborne health risk posed by poultry (see Table 4.1). An AMRS prevalence of 8.5% is assumed for all groups.

Summary statistics are presented below (see table 4.2) for scenarios where 15% of poultry being consumed in New Zealand comes from EU Member States in different groups. At this substitution level (considered to be the likely upper limit), it is highly unlikely that there will be a measurable increase in the total human salmonellosis burden in New Zealand for imports from most Member States (i.e. Groups 1 and 2). This is also true for the ‘all EU’ situation using “production corrected” inputs to the modelling process.

For Groups 3 and 4, the simulation suggests some increase in the burden of salmonellosis. It should be noted that these estimated increases will be significantly less if the level of substitution of imported poultry from these Member States is less.

It is clear that risks from poultry consumption if there was a 15% substitution of New Zealand product with that from EU Member States in Groups 1 and 2 would remain very similar. A risk management decision is needed on whether or not increases in risk that are estimated to occur from imports of poultry from Groups 3 and 4 would be within an acceptable range.

2 Evaluation of foodborne and other pathways for exposure of New Zealanders to *Salmonella*

2.1 Summary

The scientific evaluation of foodborne and other pathways for exposure of New Zealanders to *Salmonella* employed two analytical approaches. The first, the main analysis, involved the collation and review of epidemiological reports and expert opinion on human *Salmonella* cases. The second investigated the probabilistic association between the prevalence of *Salmonella* subtypes in meat products and in eggs and the frequency of isolation from human cases, weighted by food consumption.

The main conclusions in the first analysis were that over the period 1995 to 2003, 63% of cases arose from foodborne exposure, poultry was the dominate pathway, some foods previously considered to be 'high risk' either make a very small contribution to the human burden (ice cream, desiccated coconut, spices) or do not register at all (peanut butter). A significant number of cases of *Salmonella* are due to imported foods e.g. all tahini and sesame seeds are imported and 83 cases a year are attributable to these imported foods; 22 cases are attributable to imported desiccated coconut and spices.

Other transmission pathways of importance were direct animal-to-human transmission, overseas travel, and a range of environmental sources.

The reported rate of 'antibiotic multi-resistant *Salmonella*' (AMRS) in New Zealand is low. Sporadic infection with this type of *Salmonella* may potentially arise from any of the pathways identified in the study.

In the second analysis, poultry was also ranked above other meat products, although in 2003 and 2004 the difference between poultry and the other products (beef/veal, pork, lamb/mutton and eggs) had decreased. Of note is that in contrast to the first analysis, eggs were ranked low. It was concluded that the high incidence of egg associated human salmonellosis overseas has unduly

influenced epidemiological investigations of foodborne outbreaks of salmonellosis in New Zealand.

2.2 Introduction

New Zealanders are exposed to *Salmonella* by several pathways but the contribution of food relative to other pathways has not been scientifically evaluated. Food imported from other countries contributes in some proportion to the overall foodborne *Salmonella* burden and this constitutes a further risk management issue. Unlike a number of other developed countries, New Zealand has a low occurrence of more pathodenic AMRS such as *S*. Typhimurium DT 104.

The NZFSA Science Group has recently completed a detailed exposure pathway model entitled 'Analysis of Foodborne and Other Pathways for the Exposure of New Zealanders to *Salmonella'* (hereafter referred to as the primary analysis)[a].

This report summarises the key points of the scientific evaluations and presents the recommendations of the Science Group as an input to the risk management of foodborne salmonellosis in New Zealand.

2.3 Scientific evaluation

There are many uncertainties about the epidemiology of *Salmonella* exposure and human infection in New Zealand. Nevertheless, development of an exposure pathway model using data from New Zealand and overseas has provided a reasonable estimate of the proportionality of likely sources of human cases. Where the scientific data needed for particular model inputs was limited, expert opinion was used.

2.3.1 Foodborne salmonellosis

A primary model input developed from expert opinion is that there are an estimated 9,000 cases of human salmonellosis per annum in New Zealand, of which 63% are foodborne.

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[a] Anonymous, 2005. Analysis of Foodborne and Other Pathways for the Exposure of New Zealanders to Salmonella. New Zealand Food Safety Authority, Wellington, New Zealand. 1-257 pp.

Estimates of the contribution of different food categories were developed from epidemiological reports of cases in New Zealand (1998 to 2003) and Australia (1995 to 2000). This (see Appendix Table 2.4 for details) suggested that:

- Poultry and eggs dominate as foodborne exposure pathways.
- Some foods previously considered to be ‘high risk’ either make a very small contribution to the human burden (ice cream, desiccated coconut, spices) or do not register at all (e.g. peanut butter)
- A significant number of cases are due to imported foods e.g. all tahini and sesame seeds are imported and 83 cases a year are attributable to these imported foods; 22 cases are attributable to imported desiccated coconut and spices
- ‘Exotic’ serotypes including AMRS may, occasionally, be found contaminating almost any food

Failure of a food to register in the attribution process used in this study only means that a particular food type has not been identified through the human enteric disease surveillance system as making a significant contribution to the New Zealand consumers’ salmonellosis burden. In reality, virtually any food could be contaminated with *Salmonella.*

Following the above analysis, ‘case data’ were reviewed with reference to other reports, surveys, and research projects. The main conclusion was that cases attributed to poultry and eggs had been over-estimated. The revised list is shown in Appendix Table 2.5.

2.3.2 Contribution of other exposure pathways

Other exposure pathways include: travellers, live animals (including imported), wildlife, pet food, imported pet chews, and imported stock food and stock food ingredients.

Salmonellosis acquired overseas is estimated to be 6.5% of the total burden. Travellers probably play a significant role in the introduction of exotic serotypes, including those of particular concern, such as the AMRS *S.* Typhimurium DT 104 and *S*. Newport.

It is estimated that approximately 10% of human salmonellosis in New Zealand is acquired through direct contact with live animals.

Live animal imports constitute a potential pathway for the introduction of *Salmonella*, including those exotic serotypes of particular concern (e.g. *S.* Typhimurium DT 104 and *S*. Newport). The actual importance of any particular species would depend, *inter alia,* on the numbers imported. After travellers, imported animals are probably the most important non-food pathway for the introduction of exotic serotypes

While the contribution of pet food to the overall human *Salmonella* burden is likely to be insignificant in comparison to food, imported pet chews may be a significant pathway due to the makeup (e.g. relatively unprocessed materials such as jerky, rawhide bones, dried pigs' and/or cows' ears, snouts, trotters, pizzles) for the introduction of exotic serotypes. Similarly, the contribution of stock feeds to the overall human *Salmonella* burden is likely to be insignificant in comparison to food but may be a pathway for the introduction of exotic serotypes.

The same applies to wild birds as an exposure pathway.

2.3.3 Direct person-to-person spread

The rate of direct person-to-person transmission of *Salmonella* in New Zealand is estimated by expert opinion to be approximately 5%.

2.3.4 Relative contribution of all exposure pathways to human salmonellosis

Relative contributions are presented in Tables 2.1 and 2.2.

Table 2.1: Summary of the contribution of all exposure pathways to total estimated human salmonellosis in New Zealand

Pathway	Cases	% of Total
Foodborne	5,670	63.00%
Animal to person	900	10.00%
Travel	585	6.50%
Person to Person	450	5.00%
Unknown	1,395	15.50%
Total	**9,000**	**100.00%**

Table 2.2: The contribution of different pathways to total estimated human salmonellosis in New Zealand

Pathway	Cases	% of Total
Foods		
Miscellaneous other	2,765	30.72%
Poultry domestic	937	10.41%
Eggs	595	6.61%
Meat Products (RTE)	335	3.72%
Beef	210	2.33%
Pork	210	2.33%
Sheep meat	125	1.39%
Vegetables	85	0.94%
Fruit	85	0.94%
Shellfish	85	0.94%
Crustaceans	85	0.94%
Tahini	85	0.94%
Milk	11	0.12%
Milk Powder	11	0.12%
Cheese	11	0.12%
Ice Cream	11	0.12%
Desiccated coconut	11	0.12%
Spices	11	0.12%
Other		
Animal to person	900	10.00%
Travel	585	6.50%
Person to Person	450	5.00%
Unknown	1,395	15.50%
Total All	**9,000**	**100.00%**

2.4 Results of most significance for risk management decisions

2.4.1 Sources

New Zealand consumers contract salmonellosis from a wide range of domestically-produced foods.

In deciding on prioritisation of risk management options to improve the situation, risk managers must first consider the overall proportion of 'ordinary' (antibiotic susceptible) cases attributed to a particular pathway and the opportunities for risk management. It is clear from the 1995 to 2003 case data that to significantly reduce foodborne salmonellosis in New Zealand priority had to be given to enhancement of food safety controls for poultry. There is strong evidence that increasing application of more stringent controls in this sector during the study period in fact had a significant influence in reducing transmission rates (see Section 2.6).

The current programme for monitoring of imported foods is based on historical approaches and is misdirected and needs to be replaced with a risk-based programme. This strategy is included in the current "Imported Foods Review" action plan being applied by the NZFSA Domestic Standards Group.

2.4.2 Sources of cases of infection with AMRS

In deciding on risk management options, risk managers must also consider the more severe health consequences that may be associated with human cases caused by AMRS. For example S. Typhimurium DT 104 is of concern because it is resistant to multiple antibiotics and is associated with a higher hospitalization rate and case fatality rate. Multi-drug resistant S. Newport is also of concern.

Antimicrobial susceptibility of *Salmonella* from human, animal and the environment is monitored by the Institute of Environmental Science & Research Ltd. (ESR)[b]. During 2005 a representative sample of 616 non-typhoidal *Salmonella* were tested for antimicrobial susceptibility. Eight (8) out of 318 (2.5%) human isolates were resistant to 5 or more antimicrobials[c]. None of the animal or environmental isolates showed this level of resistance. Of much

[b] see http://www.surv.esr.cri.New Zealand/antimicrobial/salmonella.php

interest, the proportion of organisms exhibiting multiple resistance was significantly higher (P=0.0011) from those cases who had travelled overseas recently.

The prevalence of multi-resistant *S*. Typhimurium DT104, which is common in many countries, continues to be low in New Zealand, with only one isolate identified in 2005 and a total of 35 isolates in the last 10 years.

Where the model identified that an imported food type or other exposure pathway had a significant probability of carrying AMRS, a weighting in terms of potential risks was applied. A 'severity factor' of 10 was applied i.e. estimation of a single case of an AMRS would result in 10 ordinary cases being apportioned in the model. This is a highly precautionary weighting (see Part 4). As a result of the epidemiological analysis of the likely presence of 'AMRS' cases from food exposure pathways, the 'severity factor' was applied to imported beef (4% of cases) and imported crustaceans (58% of cases). Deterministically this resulted in numeric changes of less than one human case, thus the number for foodborne derived cases were not changed.

Overall the data from and modelling of cases of salmonellosis in New Zealand suggested that currently food (especially imported food) has a minimal effect on the incidence of ARMS human cases. There is a continuous low level of exposure via other pathways and this is either uncontrollable (e.g. travellers, wild birds) or unlikely to be significantly reduced by new controls on food (e.g. the wide range and volume of imported foods that have the potential to carry AMRS).

2.5 WTO SPS obligations

For imported foods, WTO SPS obligations need to be considered in light of the above results. Given the requirement for risk assessment, consistency and non-differential treatment, the outputs from any import controls for specific foods need to be viewed in terms of the outputs from parallel controls in place for domestic foods. If higher intensity controls are applied to specific imported food types, they need to be justified by a risk profiling process, as a minimum.

[c] personal communication Helen Heffernan, ESR, Wellington.

2.6 Validation of the modelling approach

A further method was developed by the Science Group to investigate the association between the prevalence of *Salmonella* serotypes and phage-types (hereafter called subtypes) found in foodstuffs and those isolated from human cases. This general method is being utilised in the Netherlands and Denmark to estimate the relative contribution of food groups to the overall *Salmonella* public health burden.

In this validation model, the objective was to rank the contribution of beef/veal, pork, lamb/mutton, chicken and eggs. The prevalence data were compared and weighted by consumption of these foods. Uncertainty and sampling variation was included. The results are expressed as expected number of cases that can be attributed to a food group. Data from the years 2002, 2003 and 2004 were modelled. The results, with the upper 95 percentiles, are illustrated in Figure 2.1.

Of note is the considerable and steady decline in cases attributed to chicken over the three years, while other sources remained largely static. In 2004 there is a significant reduction in cases attributed to beef/veal.

This validation exercise shows good conformance with the results from the primary scientific evaluation. The only significant difference relates to the lower proportion of human cases attributed to eggs consumed in New Zealand in this model compared to the primary model. It is thought that this difference is due to a historical 'mind-set' in public health foodborne outbreak investigators in New Zealand that eggs are a key source of salmonellosis because of their dominant position in other countries (i.e. due to *Salmonella* Enteriditis). This may have introduced an upward bias during disease outbreak investigations that provided inputs to the primary model.

Figure 2-1 Results of the risk attribution analysis using the association between *Salmonella* subtypes isolated from human cases and from foods

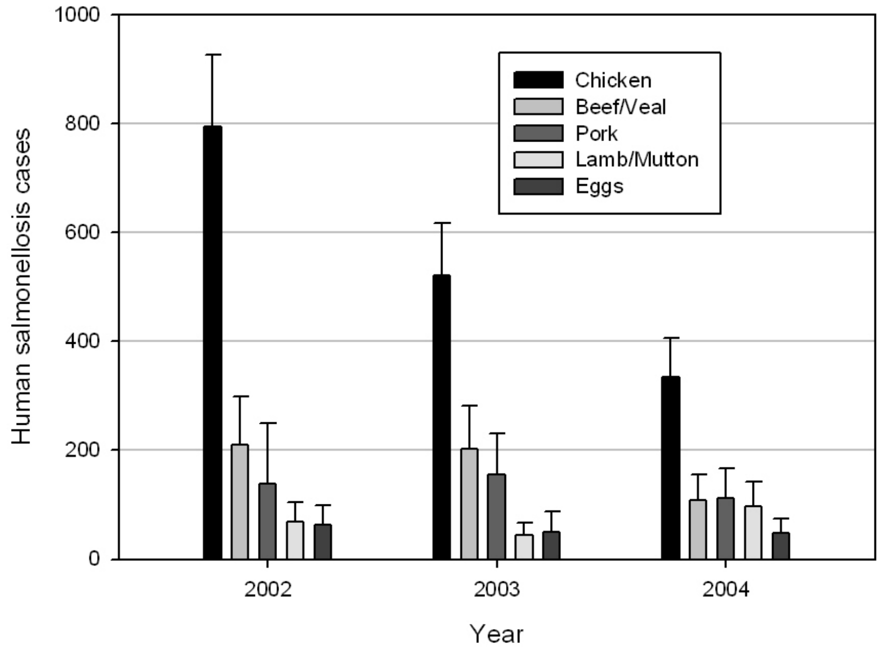

Table 2.4 Assessed contribution of food sub-categories to the occurrence of salmonellosis outbreaks in New Zealand. See section 2.3.1.

Food	**Initial Cases**	**Initial % of Total Food**
Miscellaneous other	2274	40.1%
Poultry domestic	1253	22.1%
Eggs	794	14.0%
Meat Products (RTE)	335	5.9%
Beef	210	3.7%
Pork	210	3.7%
Sheep meat	125	2.2%
Vegetables	85	1.5%
Fruit	85	1.5%
Shellfish	85	1.5%
Crustaceans	85	1.5%
Tahini	85	1.5%
Milk	11	0.2%
Milk Powder	11	0.2%
Cheese	11	0.2%
Ice Cream	11	0.2%
Desiccated coconut	0	0.0%
Spices	0	0.0%
Total Food	**5670**	**100.0%**

Table 2.5 Revised assessed contribution of food sub-categories to the occurrence of salmonellosis outbreaks in New Zealand. See section 2.3.1.		
Food	**Revised Cases**	**Revised % of Total Food**
Miscellaneous other	2765	48.8%
Poultry domestic	937	16.5%
Eggs	595	10.5%
Meat Products (RTE)	335	5.9%
Beef	210	3.7%
Pork	210	3.7%
Sheep meat	125	2.2%
Vegetables	85	1.5%
Fruit	85	1.5%
Shellfish	85	1.5%
Crustaceans	85	1.5%
Tahini	85	1.5%
Milk	11	0.2%
Milk Powder	11	0.2%
Cheese	11	0.2%
Ice Cream	11	0.2%
Desiccated coconut	11	0.2%
Spices	11	0.2%
Total Food	**5668**	**100**

3 An investigation of the effect of importing Bernard Matthew Foods Ltd. turkey meat preparations from the United Kingdom on human salmonellosis in New Zealand

3.1 Summary

The quantitative framework described in Section 2 was used to estimate the burden of human salmonellosis that would likely occur in New Zealand as a result of the importation of Bernard Matthew Foods Ltd. turkey meat ‘nugget-like’ products from the United Kingdom. The simulation was carried out using model inputs from the United Kingdom, the specific processor, and the controls currently in place for turkey meat preparations. Thus the scientific evaluation is specific to this scenario.

The model estimated that an extra 9 cases of foodborne salmonellosis would arise on an annual basis in New Zealand consumers if consumption of turkey products in New Zealand increased by 20% and Bernard Matthew Foods Ltd. turkey meat ‘nugget-like’ products were the source. Against a background of an estimated total 5,700 cases, this number has no biological or statistical significance.

The model was also used to estimate any higher health burden arising from the potential presence of ‘antibiotic multi-resistant *Salmonella*’ (AMRS). There was a high level of uncertainty in the model inputs, with some data indicating that the contamination rate of Bernard Matthews Foods Ltd. turkey products with AMRS may be as low as 0.26%. Even when a conservative assumption of 5% of cases being due to AMRS was made, there was no measurable increase in *Salmonella* burden for New Zealand consumers above background in terms of “nominal” cases. In a secondary analysis, again assuming 5% of human cases would be due to AMRS, a stochastic simulation method indicated that there was an 63% probability that no AMRS human cases would occur, and a 30% probability that

one case would occur. Thus against an estimated background of range of 18 to 62 of notified AMRS per annum (see Section 4), this simulation further illustrated the extremely minor changes in overall disease burden that might occur on the basis of "nominal" cases.

3.2 Introduction

The objective of this investigation was to estimate the burden of human salmonellosis, caused by infection with both 'ordinary' and AMRS that would be likely to occur as a result of the importation of Bernard Matthew Foods Ltd. (BMFL) turkey meat 'nuggets-like' products from the United Kingdom.

This study is an extension of the generic model using the most likely sources of human exposure to *Salmonella* in New Zealand[d]. This report summarises the scientific inputs to the model simulation and presents the estimate of disease burden on the basis of "nominal" cases..

3.3 Scientific evaluation

The chain of calculations used to estimate the likely additional human cases of salmonellosis are shown in Figures 3.1 and 3.2. These include a number of assumptions, as follows. (Note: References to the sub-sections have been included on the links in the figures).

3.3.1 Turkey meat production

The most recent figure for turkey meat production in New Zealand is from 1996[e]. In that year 1,976 tonnes of turkey were produced compared to 87,165 tonnes of chicken; i.e. turkey production was 2.3% that of chicken.

It is assumed that this proportionality still exists.

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[d] Anonymous, 2005. Analysis of Foodborne and Other Pathways for the Exposure of New Zealanders to Salmonella. New Zealand Food Safety Authority, Wellington, New Zealand. 1-257 pp.

[e] personal communication Ronald Mair, Information Analyst, Statistics New Zealand, Christchurch to Stuart MacDiarmid.

3.3.2 Salmonellosis cases arising from poultry.

In the recent analysis of pathways of human exposure to the *Salmonella*, it was estimated that 937 cases per year originated from poultry (Anonymous, 2005).

3.3.3 Salmonellosis cases arising from turkey

It is assumed that the proportion of poultry-borne salmonellosis attributed to turkey will be 2.3% of the total attributed to poultry. That is 0.023 * 937 = 21.6, rounded up to 22 cases. Recent data from the United Kingdom suggests that salmonellosis rates in poultry are approximately twice that occurring in New Zealand (see Section 4). Thus, it will be assumed that 44 cases could arise from this amount of product imported from the UK.

3.3.4 Effect of importing BMF's turkey preparation on poultry consumption in New Zealand

An import risk analysis[f] conducted by MAF Regulatory Authority in 1999 stated that BMFL hoped to gain a market share equivalent to 20% of the turkey consumed in New Zealand. There is no reason to assume that the consumption of domestic turkey meat would decrease. Therefore, the consumption of BMFL turkey 'nugget-like' preparations would represent a 20% increase in total turkey consumption.

The number of additional cases that could therefore arise is 9 (i.e. 20% of 44 rounded up)

3.3.5 Estimate of contamination with AMRS

Recent data[g] from the Great Britain show that in 2004 12.8% (31/243) of isolates from *Salmonella* surveillance in turkeys were the AMR subtype Typhimurium DT 104.

The import risk analysis conducted by MAF Regulatory Authority in 1999 cited results of *Salmonella* testing conducted of turkey products by BMFL.

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[f] Anonymous, 1999. Import risk analysis: chicken meat and chicken meat products; Bernard Matthews Foods Ltd turkey meat preparations from the United Kingdom. MAF Regulatory Authority, Ministry of Agriculture and Forestry, Wellington, New Zealand.
[g] see http://www.defra.gov.uk/corporate/vla/science/science-salm-rep04.htm

Contamination rates on fresh portions over 6 months of 1996 were as shown in Table 3.1.

Assuming that the *Salmonella* contamination rate has not increased since 1996, the rate of contamination of BMFL turkey products with subtype Typhimurium DT 104 is unlikely to be greater than 0.26% (i.e. 12.8% * 2%).

Table 3.1: Monthly *Salmonella* test results of turkey products from Bernard Matthews Foods Ltd

Month	Number tested	Number positive	% positive
June	83	1	1.2
July	136	3	2.2
August	133	7	5.3
September	94	0	0
October	125	0	0
November	118	4	3.4
TOTAL	689	15	2.2

Figure 3-1 The chain of calculations used to estimate the 'nominal' number of human cases of salmonellosis (i.e. including a severity factor for multi-resistant infections) that could be attributed to importation of Bernard Matthews Foods Ltd. turkey product. Link reference numbers refer to section labels in the text.

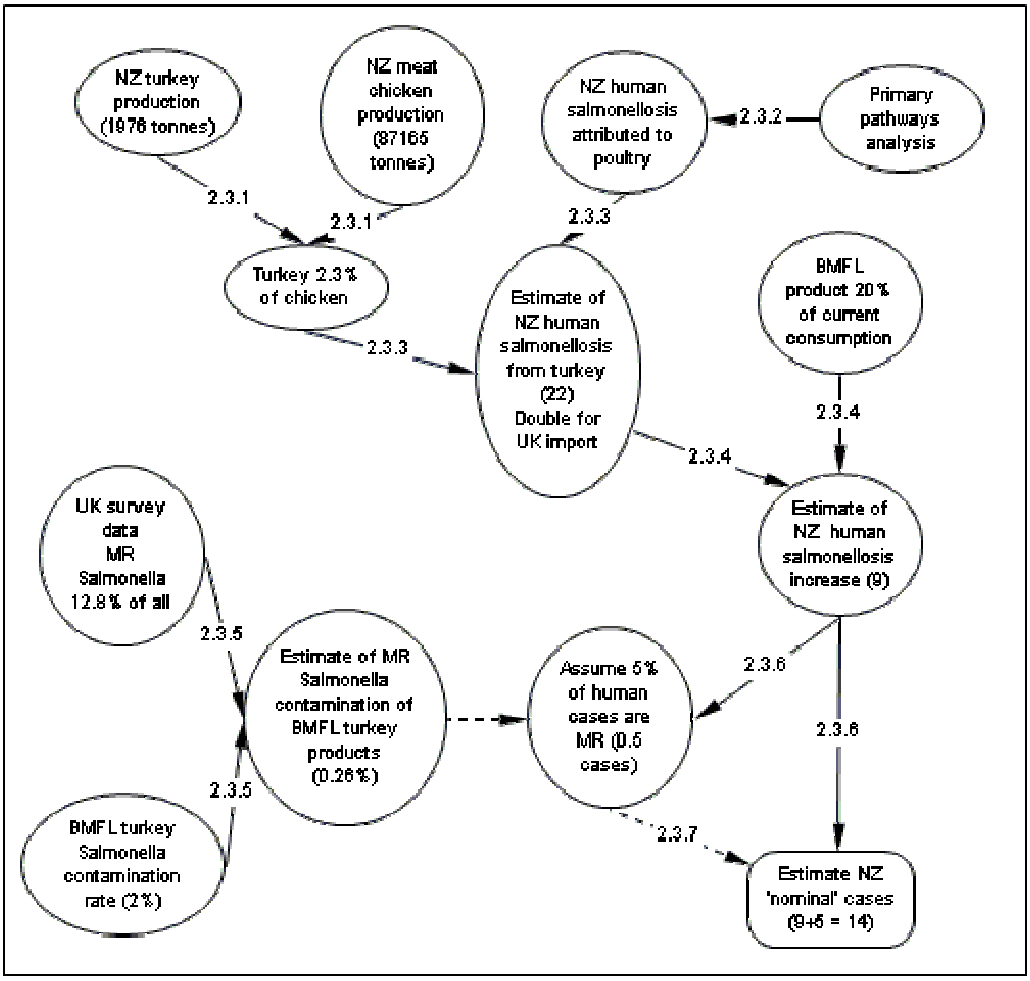
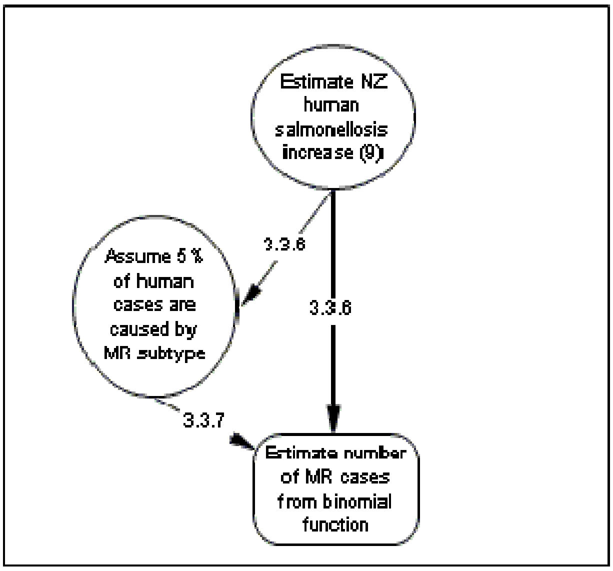


Figure 3-2 The second method used to estimate human cases of AMRS infection.



3.3.6 Estimate of MR human cases

Although, as described in section 3.5, the contamination of BMFL turkey preparations with subtype Typhimurium DT 104 is unlikely to exceed 0.26%, a highly precautionary assumption was made that 5% of human cases could be caused by this or a similar organism. This 20 fold factor is assumed to take account of the higher infectivity that might be associated with AMRS, even though this has not been scientifically demonstrated to be the case.

3.3.7 Estimate of "nominal" additional human cases and actual AMRS cases.

Two methods were used to incorporate the public health impact of AMRS cases. In the primary analysis, a 'severity factor' of 10 was applied; i.e. estimation of a single case of a 'severe' subtype would result in 10 'ordinary' cases being apportioned in the model. In the secondary analysis, the probabilities of cases being the result of infection with an AMRS were estimated via stochastic software; i.e. simulation to estimate the likely number of extra cases that would be caused by infection with an AMRS organism.

3.4 Results of most significance for risk management decisions

3.4.1 Results of analyses

The chain of calculations shown in Figure 3.1 came to an estimated additional 9 human cases of salmonellosis.

Taking into consideration the additional public health impact of potential AMRS, an additional nominal 5 cases were added to this estimate (i.e. (5% of 9 =0.45) * 10). That is, the increase in human cases that it is estimated would arise from importation of BMFL turkey product is equivalent to an additional 14 cases. Thus, with importation of turkey meat preparation equivalent to 20% of domestic consumption, the burden of salmonellosis in nominal case equivalents would increase from 22 to 36. Total salmonellosis nominal case equivalents attributable to poultry would therefore rise from 937 to 973 and total nominal case equivalents over all exposure pathways would increase from 9,224 to 9,260 per annum.

The results of the second analysis, an estimate of the probability of the number of AMRS cases occurring, are as shown in Table 3.2. That is there is a 93% probability there would be zero or only one AMRS human case within the additional 9 cases (with a 63% probability of no AMRS cases and 30% of one being an AMRS case).

Table 3.2: Estimated probability of the number of human cases due to antibiotic multi-resistant *Salmonella* (AMRS) that would arise from the given volume of imported Bernard Matthews Foods Ltd. turkey product.

Number of AMRS Cases	Probability	Cumulative Probability
0	63%	63%
1	30%	93%
2	6%	99%
3	1%	100%

3.5 Overall estimate of disease burden

It is probable that the importation from the United Kingdom of Bernard Matthews Foods Ltd. turkey meat preparation in a volume equivalent to 20% of current domestic turkey consumption would not result in any detectable increase in the salmonellosis burden borne by the New Zealand consumer. Simulation modelling suggested a nominal increase of 0.15%.

4 Risk analysis of the public health impact of human salmonellosis that could arise from the importation of poultry or turkey products from throughout the European Union

4.1 Summary

The objective of this analysis was to assess relative salmonellosis risks that may be posed by poultry or turkey imports from throughout the European Union (EU). This study builds on the data and methodology presented in Sections 2 and 3 and presents a summary of scientific findings.

Data reported by Member States indicate there is a wide variation in prevalence for both 'ordinary' *Salmonella* and AMRS across the EU. Of note is that in some cases the sample sizes were very small leading to large statistical uncertainty intervals. Survey methods were not reported and thus it is not possible to comment on how representative the reported figures are.

The available data indicates that the prevalence of *Salmonella* in poultry in EU Member States is not directly comparable to New Zealand. Prevalence ratios are less than 1 for only Sweden, Finland, Spain and Ireland. Prevalence ratios for most other countries are less than 5, but one (Cyprus) is above 10. Likewise the prevalence of 'antibiotic multi-resistant *Salmonella'* (AMRS) in New Zealand (2005, human isolates 2.5%, animal and environmental isolates 0%) is lower than reported from the EU (mean poultry isolates 8.5%).

Salmonella prevalence and poultry production in the EU are often disparate. A 'production corrected' prevalence which more accurately reflects overall consumer exposure in the EU was calculated. This figure 4.24% is 1.35 times a similar figure (3.14%) calculated from plant production data in New Zealand.

A stochastic model of the total human burden of salmonellosis in New Zealand was constructed and a variety of poultry import scenarios were trialled. A key

assumption of the modelling is that the prevalence of *Salmonella* in poultry is proportionally linked with the prevalence of human salmonellosis.

The public health impacts were assessed in terms of officially notified numbers of human cases, AMRS cases, cases hospitalised, cases that die and cases where there is long term disability.[h]

A gradual increase in estimated disease burden occurs as the disparity between the level of *Salmonella* contamination of New Zealand poultry and substituted EU poultry increases. As a consequence, different EU Member States are grouped as to the likely level of relative foodborne health risk posed by poultry (see Table 4.1). An AMRS prevalence of 8.5% is assumed for all groups.

Table 4.1 Suggested grouping of European Member States with reference to public health impacts subsequent to importation of poultry or turkey products.

Group	EU/NZ Prevalence Ratio	EU Member States	Species
1	≤ 1	Sweden, Finland, Spain, Ireland	Poultry
2	1 to 5	Italy, United Kingdom, Slovenia, Estonia, Germany, Belgium	Poultry
		United Kingdom, Ireland, Austria, Germany	Turkey
3	6 to 10	United Kingdom	Game Fowl
4	11 to 20	Cyprus	Poultry

[h] This was based on the assumption that over a number of years a mean of 15% of cases are notified and a mean of 10.4% of total cases are due to exposure to poultry. It was further assumed that 12.5% of the notified 'ordinary cases' require hospitalisation and that the case fatality for each is less than 1%. For AMRS infection it was assumed 25% would be hospitalised and the case fatality is from 1% to 2%. Further, it was assumed that 1.7% of all notified cases would result in some form of long term disability.

Summary statistics are presented below (see table 4.2) for scenarios where 15% of poultry being consumed in New Zealand comes from EU Member States in different groups. At this substitution level (considered to be the likely upper limit), it is highly unlikely that there will be a measurable increase in the human salmonellosis burden in New Zealand for Member States in Groups 1 and 2. This is also true for the 'all EU' situation where product is imported proportional to Member State production.

For Groups 3 and 4, the simulation illustrates some increase in the burden of salmonellosis. It should be noted that these estimated increases will be much less if the total volume of imported poultry is spread over Member States in different groupings. A risk management decision is needed on whether or not increases in risk that are estimated to occur from imports of poultry from individual countries in Groups 3 and 4 would be within an acceptable range.

Table 4.2 Estimates of public health consequences, in terms of **officially notified human cases of salmonellosis, notified human cases of antibiotic multi-resistant *Salmonella* (AMRS), notified cases hospitalised, notified cases that die and notified cases with long term problems,** with 15% substitution of imported poultry products for domestically products. An 'EU production corrected' figure and the current New Zealand (NZ) data derived from the model are also listed.

Group	**Cases**		**AMRS Cases**		**Number Hospitalised**		**Number Deaths**		**Number Long Term Problems**	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
1	1,280	1,402	19	64	151	194	0	3	15	31
2	1,320	1,465	23	69	157	203	0	3	16	32
3	1,406	1,569	30	77	169	217	0	3	17	34
4	1,543	1,954	45	106	192	264	0	4	20	40
EU	**1,297**	**1,419**	**21**	**66**	**154**	**197**	**0**	**3**	**15**	**32**
NZ	**1,288**	**1,410**	**18**	**63**	**152**	**196**	**0**	**3**	**15**	**31**

4.2 Introduction

The outcome of the previous part of this report is specific to evaluation of the human health risks associated with importing turkey meat preparations produced by Bernard Matthew Foods Ltd. in the United Kingdom. The objective of this Part is to apply the methods developed in Parts 2 and 3 to assess risks that may be posed by poultry or turkey imports from other producers in the United Kingdom, or from other EU Member States. Disease burden arising from 'ordinary' and AMRS are considered.

4.3 Method

4.3.1 *Salmonella* contamination of poultry in New Zealand

Salmonella process monitoring data from the National Microbiological Database (NMD) were used to assess the prevalence of contamination of carcases in New Zealand.. Results from 5 years were available, including results for each processing plant. For the 2005/2006 year New Zealand 'a production corrected prevalence' was calculated. Using the approximate through-put from each plant and the reported plant *Salmonella* contamination prevalence, the total number of contaminated carcases released onto the New Zealand market was estimated. The corrected prevalence was calculated by dividing this by the total New Zealand production.

Information on the occurrence of antibiotic multi-resistant *Salmonella* (AMRS) in New Zealand was taken from reports of the national ESR Salmonella typing laboratory[i]. The criterion for an AMRS is resistance to five or more anti-microbial agents.

4.3.2 Salmonella contamination of poultry and turkey products in the EU

The main source of data was the report 'Trends and sources of zoonoses, zoonotic agents and antimicrobial resistance in the European Union in 2004'[j] which was published by the European Food Safety Authority (EFSA) in March

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[i] see http://www.surv.esr.cri.New Zealand/antimicrobial/salmonella.php and personal communication Helen Heffernan, ESR, Wellington.
[j] http://www.efsa.eu.int/science/monitoring_zoonoses/reports/1277_en.html

2006. This contains reports from the Member States of *Salmonella* at different points in the food chain, including AMRS in poultry products. Limited data for turkey products were also available.

Other sources of information were the 2003 United Kingdom Food Standards Agency report 'UK-wide Survey of *Salmonella* and *Campylobacter* Contamination of Fresh and Frozen Chicken on Retail Sale'[k] and the 'DEFRA Zoonosis Report United Kingdom 2004'[l].

The number tested and number *Salmonella* positive were listed in most of these reports. The 95% confidence limits of the prevalence were calculated to estimate the uncertainty of the points reported.

To estimate an 'all-EU prevalence' of *Salmonella* contaminated in poultry a 'production corrected' figure was calculated. FAO chicken meat production figures in Member States for 2004 were converted to number of birds, assuming an average bird weight of 1.74 kg. The total number of contaminated birds released onto the market in these countries was then estimated from the reported prevalence rates (where this was available) and an overall figure for the EU then calculated.

4.3.3 Comparison of the Salmonella prevalence of poultry and turkey products in the EU and New Zealand

The ratio between the prevalence reported by the EU Member States and that in New Zealand was calculated. To assess the uncertainty of these estimates beta-pert distributions (minimum=lower 95% CL, most likely=prevalence point estimates, maximum=upper 95% CL) of the EU data were used (i.e. the numerator). The production corrected prevalence for New Zealand was the denominator. The results were reported as the mean and lower and upper 90 percentile simulation limits.

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[k] http://www.food.gov.uk/multimedia/webpage/111802
[l] http://www.defra.gov.uk/animalh/diseases/zoonoses/zoonoses_reports/zoonoses2004.pdf

4.3.4 The public health impact of human salmonellosis

A model of the total officially notified human *Salmonella* cases using the human 2005 surveillance report[m] was developed. This was based on the assumption that over a number of years a mean of 15% of cases are notified and a mean of 10.4% of total cases are due to exposure to poultry (see Section 2). It was further assumed that 12.5% of the notified 'ordinary cases' require hospitalisation and that the case fatality for each is less than 1%. For AMRS infection it was assumed 25% would be hospitalised and the case fatality is from 1% to 2%. Further, it was assumed that 1.7% of all notified cases would result in some form of long term disability.

A stochastic model using the Excel add-in @Risk software was used to model the variation in the total number of human cases, cases of AMRS infection, number hospitalised, number with long term sequelae and deaths that one would expect per annum. Simulations were run for between 5% and 15% substitution of domestic by EU imported poultry and for poultry prevalence ratios of human salmonellosis compared to the current New Zealand situation of 1 to 1, 1 to 2, 1 to 5, 1 to 10, and 1 to 20.

4.4 Results

4.4.1 Salmonella contamination of poultry and turkey products in New Zealand

The NMD annual data are shown as a line graph in Figure 4.1. The 5 year cumulative figure, 2.14%, (167 / 7,795) and the production correction figure, 3.14%, for 2005/2006 are also shown. This latter higher figure arose as one plant with a through-put in excess of 10 million birds (11% of total production) recorded a prevalence of 18%.

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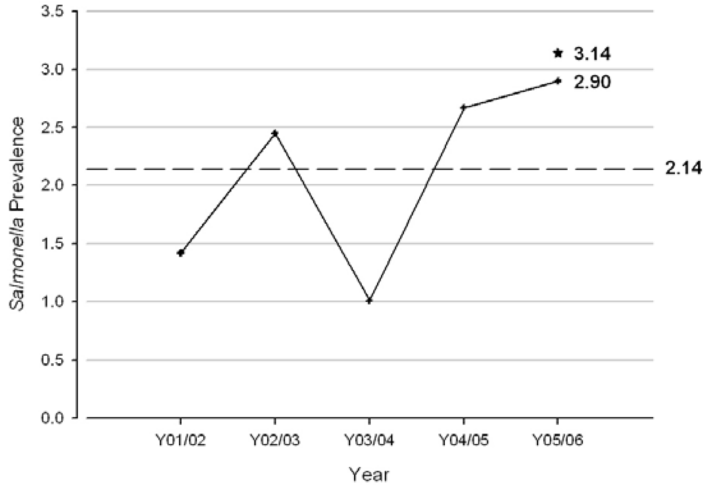
[m] Notifiable and Other Diseases in New Zealand Annual Report 2005, ESR (see http//www.surv.esr.cri.New Zealand)

Figure 4-1 *Salmonella* prevalence in poultry carcases at processing as per the National Microbiological Database (NMD) for the years 2001/2002 to 2005/2006. The cummulative prevalence (2.14%) and the 'production corrected prevalence' (3.14%) for 2005/2006 are also shown.



In 2005 a random sample of 616 *Salmonella* isolates was tested for antimicrobial resistance, 318 human and 298 animal/environmental isolates. Eight of the former (2.5%) were AMRS; none of the latter.

4.4.2 *Salmonella* contamination of poultry and turkey products in the EU

4.4.2.1 Overview of the prevalence of *Salmonella* in poultry and turkeys.

The reports received from Member States are summarised in Figures 4.2 to 4.4. The range of *Salmonella* prevalence was considerable, from 0.1% to 36.6%. Likewise, the number of samples tested varied considerably, for example for poultry from 30 to 7,239, and thus the confidence intervals around some prevalence points are very large. In those Member States with monitoring and control programmes (see Figure 4.2) the *Salmonella* prevalences were lower and the confidence intervals narrower. Likewise, the results from some large surveys were reported from the UK (see Figure 4.3).

Although the data are sparse, the Salmonella prevalence figures for turkey appear higher than for chicken (Figure 4.4).

There is an important question as to where in the food chain samples should be taken, accepting that there may be marked differences. One would assume that from a food safety aspect, the closer to the point of 'consumer exposure' the better; i.e. from a practicable point–of-view retail surveys. In this regard, of interest is the variable prevalence reported at processing and at retail (Figure 4.4), and the somewhat unexpected markedly higher figures for frozen product (Figure 4.5). It would seem that depending on any given situation, different standard sampling methods would need to be defined.

Figure 4-2 EFSA reported prevalence of *Salmonella* in poultry (with 95% confidence intervals) at processing or cutting. (A reference line of 3.14% is shown, being the production corrected figure for NZ in 2005/2006)

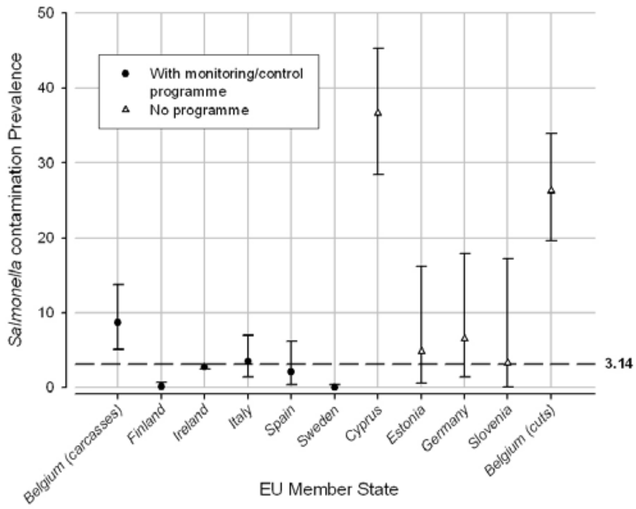


Figure 4-3 Reports from the UK of the prevalence of *Salmonella* (with 95% confidence intervals) in either raw whole chickens or fresh meat from poultry, turkeys or game fowl. Surveys were undertaken on behalf of the UK Food Standard Agency in collaboration with other agencies. (A reference line of 3.14% is shown, being the production corrected figure for NZ in 2005/2006)

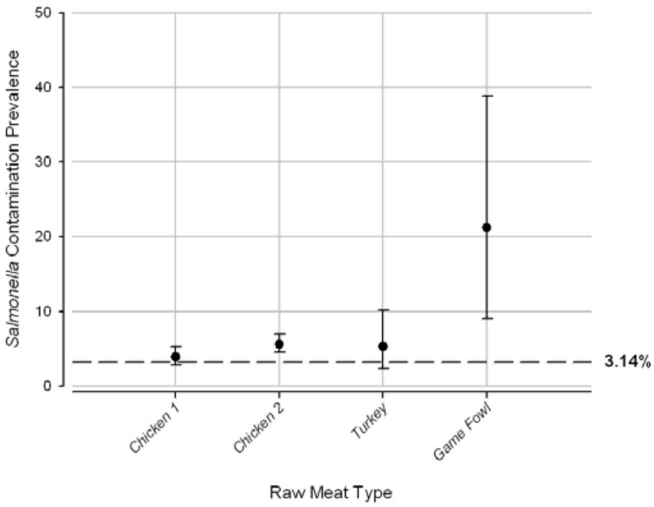
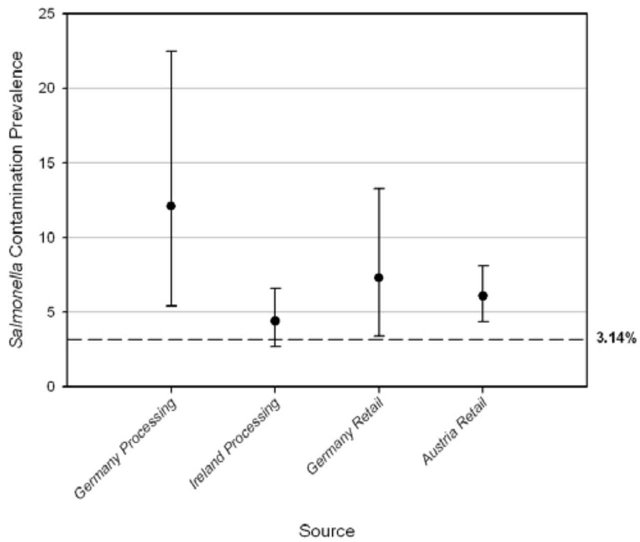


Figure 4-4 Reports of the prevalence of *Salmonella* in turkeys at either processing or retail. (A reference line of 3.14% is shown, being the production corrected figure for NZ in 2005/2006)



The data used to calculate a 'production corrected' prevalence for the EU is listed in Table 4.3. The figure is 4.24% (113,689,914 / 2,678,775,862)

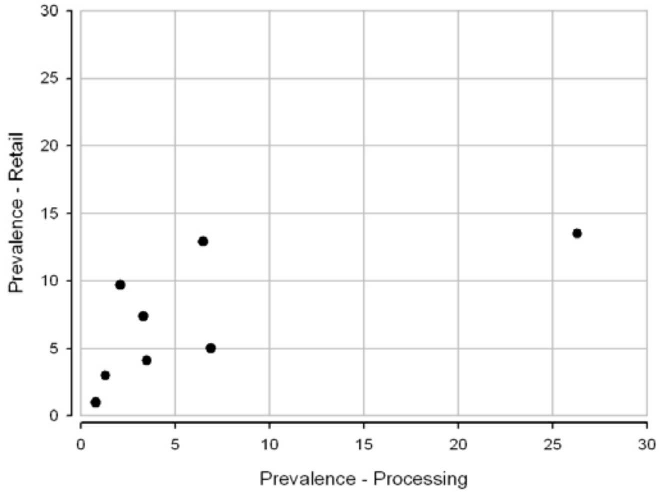
Table 4.3 Data used to estimate a EU-wide *Salmonella* contamination prevalence

Country	Production (Tonnes)	Estimated number of birds	% *Salmonella* Contamination	Number *Salmonella* Contaminated
Belgium	468,000	268,965,517	8.7	23,400,000
Cyprus	35,000	20,114,943	36	7,241,379
Estonia	15,580	8,954,023	4.8	429,793
Finland	86,970	49,982,759	0.1	49,983
Germany	609,400	350,22,9885	6.5	22,764,943
Ireland	95,000	54,59,7701	2.7	1,474,138
Italy	703,550	404,339,080	3.5	14,151,868
Spain	1,268,280	728,896,552	2.1	15,306,828
Sweden	91,200	52,413,793	0	0
United Kingdom	1,288,090	740,281,609	3.9	28,870,983
		2,678,775,862		113,689,914

4.4.2.2 Prevalence of Salmonella in poultry and turkeys at processing/retail and fresh/frozen in the EU

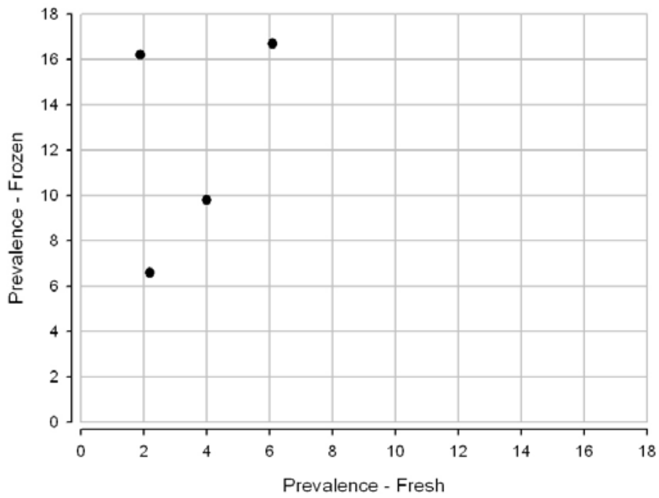
For some Member States the prevalence at processing and at retail is reported (Figure 4.5). The difference is not statistically significant (P=0.3).

Figure 4-5 Scattergram showing prevalence of *Salmonella* in chicken meat at processing and at retail.



Data on fresh and frozen product in the UK are also available (Figure 4.6). In the samples taken from England, Wales, Scotland and Northern Ireland the prevalence in frozen poultry was higher than in fresh. The difference is significant (P=0.02) and unexplained. The aggregated figures for fresh poultry is 4.0% (95% CI 3.7% to 4.7%) and for frozen poultry 10.5% (95% CI 8.8% to 12.1%).

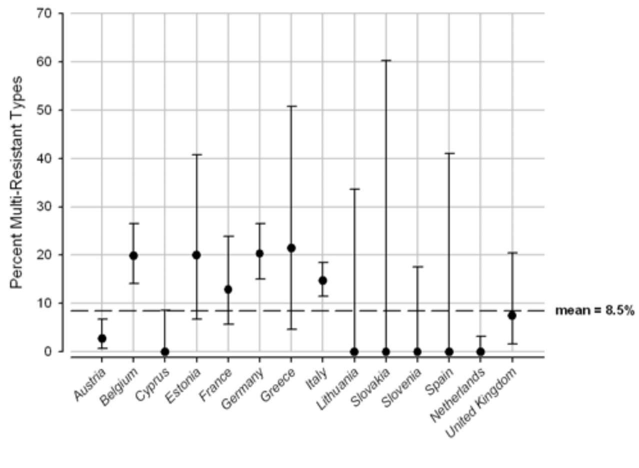
Figure 4-6 Scattergram of prevalences of *Salmonella* in fresh and frozen poultry products



4.4.2.3 Prevalence of AMRS in broiler meat in the EU

A comprehensive listing, but with some Member States limited in terms of number of cases, of the prevalence of antibiotic multi-resistant *Salmonella* in broiler meat as a percentage of isolates was published in the EFSA report (Figure 4.7). As a result the confidence intervals around some points are again very large. The mean value is 8.5% and with the exception of Austria (lower), Belgium (higher), Germany (higher), Italy (higher) and the Netherlands (lower), the 95% confidence intervals include this figure.

Figure 4-7 Reported prevalence (with 95% confidence intervals) of AMRS *Salmonella* as a percentage of isolates from broiler meat by EU Member States. The mean, 8.5%, is also shown.



4.4.3 Comparison of the *Salmonella* prevalence of poultry and turkey products in the EU and New Zealand

The prevalence ratios with lower and upper 90 percentile limits are displayed in Figure 4.8 and listed in Table 4.4. The ratio, 1.35, derived from the EU production corrected figure is also shown in Figure 4.8.

Figure 4-8 Ratio of *Salmonella* prevalences of (EU product/New Zealand poultry); mean and 90 percentiles intervals shown

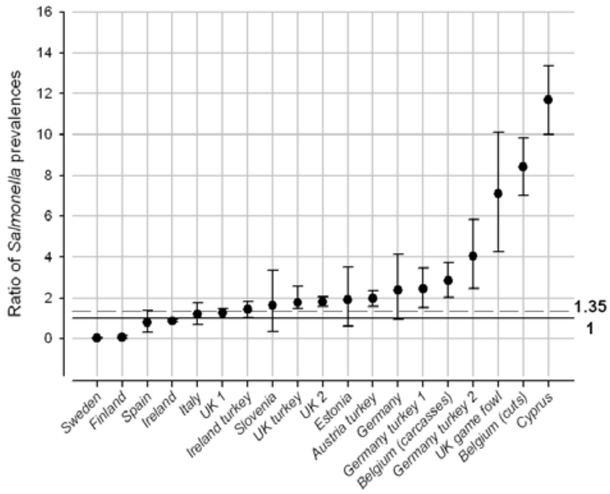


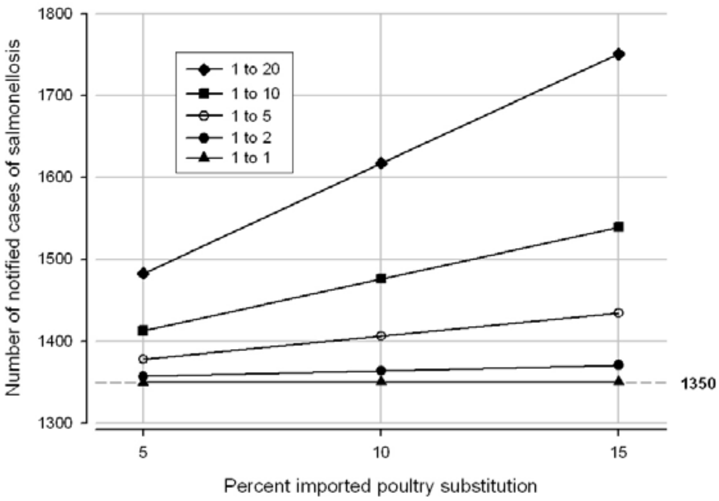
Table 4.4 Ratio of *Salmonella* prevalences of (EU product/New Zealand poultry); mean and 90 percentiles listed.

Product	EU Member State	Mean ratio	Lower 90 pc	Upper 90 pc
Poultry processing/cutting	Sweden	0.02	0.00	0.06
Poultry processing/cutting	Finland	0.06	0.01	0.13
Poultry processing/cutting	Spain	0.79	0.30	1.38
Poultry processing/cutting	Ireland	0.87	0.80	0.94
Poultry processing/cutting	Italy	1.19	0.67	1.76
Poultry retail	UK 1	1.25	1.02	1.49
Turkey processing	Ireland	1.42	1.05	1.82
Poultry processing/cutting	Slovenia	1.63	0.35	3.37
Turkey retail	UK	1.77	1.50	2.57
Poultry retail	UK 2	1.80	1.57	2.04
Poultry processing/cutting	Estonia	1.91	0.62	3.51
Turkey retail	Austria	1.96	1.60	2.34
Poultry processing/cutting	Germany	2.37	0.95	4.12
Turkey retail	Germany	2.44	1.51	3.46
Poultry processing/cutting	Belgium (carcasses)	2.84	2.01	3.73
Turkey processing	Germany	4.05	2.45	5.83
Game Fowl	UK	7.09	4.27	10.09
Poultry processing/cutting	Belgium (cuts)	8.41	7.00	9.82
Poultry processing/cutting	Cyprus	11.69	10.01	13.36

4.4.4 The public health impact of human salmonellosis

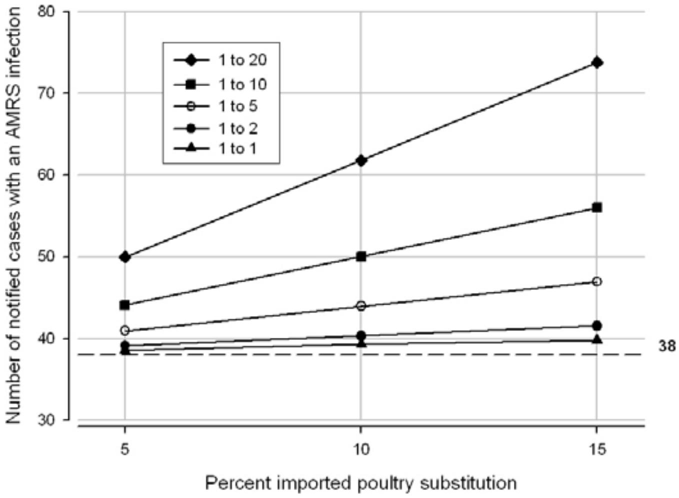
In Figures 4.9 to 4.13, mean numbers of notified human salmonellosis cases, mean numbers of notified AMRS cases, mean numbers of notified cases hospitalised, mean numbers notified cases that die and mean numbers of notified cases that result in long term disability are shown respectively for from 5% to 15% substitution of domestic product with imported product. In each figure, lines for the prevalence ratios of 1 to 1, 1 to 2, 1 to 5, 1 to 10 and 1 to 20 with respect to New Zealand cases are shown; i.e. assuming twice the poultry contamination prevalence yielded twice the human cases etc. In each scenario it is assumed that the prevalence among human cases of antibiotic multi-resistant *Salmonella* is 8.5%, the mean EU value in poultry.

Figure 4-9 Outcome (**total notified cases of human salmonellosis per annum**) of a model of salmonellosis, given from 5% to 15% substitution with imported poultry with prevalence ratios (compared to New Zealand) of from 1 to 20 and with an antibiotic multi-resistant *Salmonella* prevalence of 8.5%.



The line 'one to one' (Figure 3.8, symbol = triangles) would result in 1,352 cases per annum, approximately the same as reported currently.

Figure 4-10 Outcome (**number of notified cases of human AMRS salmonellosis per annum**) of a model of salmonellosis, given from 5% to 15% substitution with imported poultry with prevalence ratios (compared to New Zealand) of from 1 to 20 and with an antibiotic multi-resistant *Salmonella* prevalence of 8.5%.



The line ‘one to one’ (Figure 4.9, symbol = triangles) shows the effect of introduction of multiple resistant subtypes; currently there are approximately 38 notified per annum.

Figure 4-11 Outcome (**notified cases hospitalised per annum**) of a model of salmonellosis, given from 5% to 15% substitution with imported poultry with prevalence ratios (compared to New Zealand) of from 1 to 20 and with an antibiotic multi-resistant *Salmonella* prevalence of 8.5%.. The current estimated figure of 174 per annum is also shown.

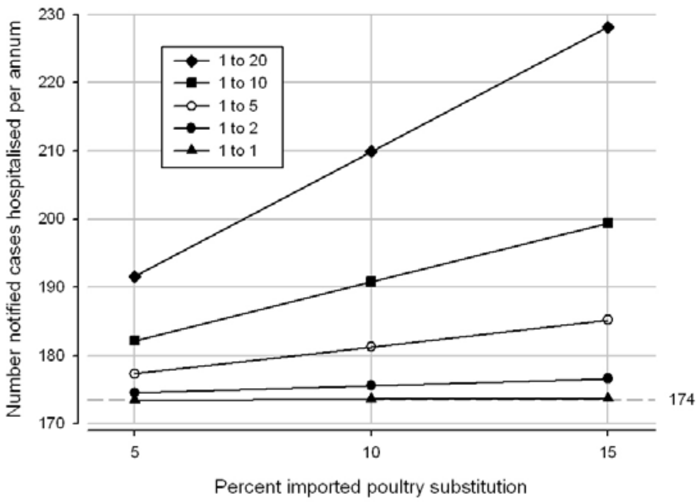


Figure 4-12 **Outcome (notified cases that die per annum)** of a model of salmonellosis, given from 5% to 15% substitution with imported poultry with prevalence ratios (compared to New Zealand) of from 1 to 20 and with an antibiotic multi-resistant Salmonella prevalence of 8.5%. The current estimated figure 0.94 per annum is also shown.

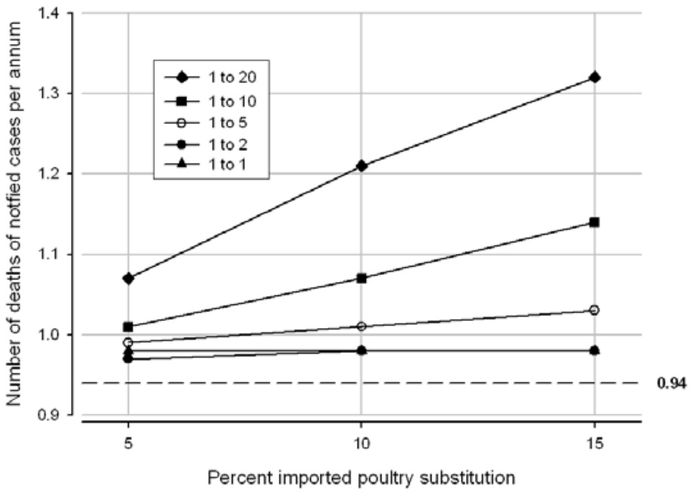
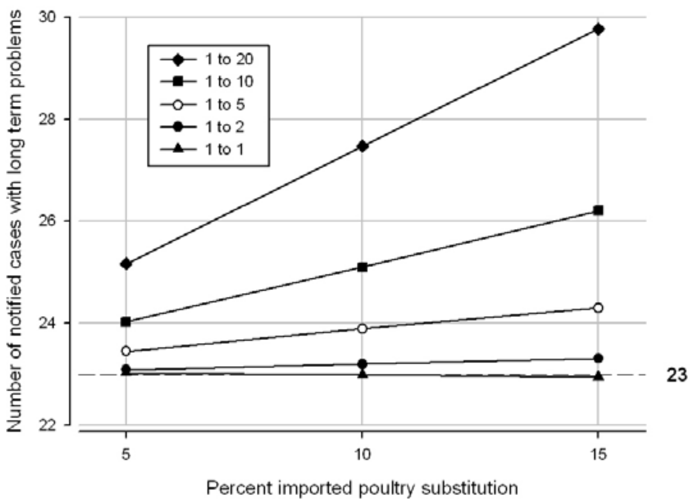


Figure 4-13 Outcome (**notified cases with long term disability per annum**) of a model of salmonellosis, given from 5% to 15% substitution with imported poultry with prevalence ratios (compared to New Zealand) of from 1 to 20 and with an antibiotic multi-resistant *Salmonella* prevalence of 8.5%. The current estimated figure 23 per annum is also shown.



4.5 Overall estimates of disease burden

A key assumption of the modelling, both in this investigation and in Sections 2 and 3 is that the prevalence of *Salmonella* in poultry is proportionally linked with the prevalence of human salmonellosis.

A series of simulations were run, assuming 15% of poultry being consumed in New Zealand comes from EU Member States, with various prevalence ranges (with reference to the reported prevalence of *Salmonella* contamination in the EU) and 8.5% of contaminants to be AMRS. At this substitution level (considered to be a likely upper limit), it was possible to group Member States (for those where data were published in the EFSA reports) into four categories (see Table 4.7). Most lie in Groups 1 and 2 and it is highly unlikely that there will be a measurable increase in the human salmonellosis burden in New Zealand. In Table 4.8 the consequences attributed to poultry with and without imports are listed. Note that it has been assumed that AMRS would not be derived from domestic poultry. In Table 4.9 the overall salmonellosis burden from all causes, including travel, are listed.

For Groups 3 and 4, the simulation outputs suggest there would be an increase in the overall burden of salmonellosis if poultry was imported from these countries alone (Table 8). Within the overall situation in New Zealand this would be a minor change. A risk management decision is needed on this potentiality.

Using the production corrected figures for the EU and NZ and at 15% import substitution the model outputs suggest there would be unlikely that there will be a measurable increase in the human salmonellosis burden in New Zealand (Table 8) where product is imported proportional to Member State production.

Table 4.7 Grouping of European Member States with reference to public health impacts subsequent to importation of poultry or turkey products.

Group	EU/NZ Prevalence Ratio	EU Member States	Species
1	≤ 1	Sweden, Finland, Spain, Ireland	Poultry
2	1 to 5	Italy, United Kingdom, Slovenia, Estonia, Germany, Belgium	Poultry
		United Kingdom, Ireland, Austria, Germany	Turkey
3	*6 to 10*	*United Kingdom*	*Game Fowl*
4	11 to 20	Cyprus	Poultry

Table 4.8 Estimates of public health consequences from *Salmonella* contaminated poultry, in terms of **officially notified human cases of salmonellosis, notified human cases of antibiotic multi-resistant *Salmonella* (AMRS), notified cases hospitalised, notified cases that die and notified cases with long term problems,** with 15% substitution of imported poultry products for domestically products. An 'EU production corrected' figure and the current New Zealand (NZ) data derived from the model are also listed.

Group	Cases		AMRS Cases		Number Hospitalised		Number Deaths		Number Long Term Problems	
	Low	High	Low	High	Low	High	Low	High	Low	High
1	109	152	0	3	10	23	0	1	0	5
2	138	228	1	11	14	34	0	1	1	6
3	240	338	8	22	27	50	0	1	2	9
4	332	540	16	40	40	77	0	2	3	13
EU	**128**	**168**	**0**	**5**	**12**	**26**	**0**	**1**	**0**	**5**
NZ	**121**	**160**	**0**	**0**	**11**	**25**	**0**	**1**	**0**	**5**

Table 4.9 Estimates of the total public health consequences of salmonellosis, in terms of **officially notified human cases of salmonellosis, notified human cases of antibiotic multi-resistant *Salmonella* (AMRS), notified cases hospitalised, notified cases that die and notified cases with long term problems,** with 15% substitution of imported poultry products for domestically products. An 'EU production corrected' figure and the current New Zealand (NZ) data derived from the model are also listed.

Group	**Cases**		**AMRS Cases**		**Number Hospitalised**		**Number Deaths**		**Number Long Term Problems**	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
1	1,280	1,402	19	64	151	194	0	3	15	31
2	1,320	1,465	23	69	157	203	0	3	16	32
3	1,406	1,569	30	77	169	217	0	3	17	34
4	1,543	1,954	45	106	192	264	0	4	20	40
EU	**1,297**	**1,419**	**21**	**66**	**154**	**197**	**0**	**3**	**15**	**32**
NZ	**1,288**	**1,410**	**18**	**63**	**152**	**196**	**0**	**3**	**15**	**31**