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RISK RANKING: UPDATED ESTIMATES OF THE BURDEN OF FOODBORNE DISEASE FOR NEW ZEALAND IN 2013

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Prepared for MPI by Peter Cressey and Dr Rob Lake (ESR)
and Dr Craig Thornley (MPI)

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Publications Logistics Officer
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Scientific Interpretive Summary

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

Risk Ranking: updated estimates of the burden of foodborne disease for New Zealand in 2013

ESR Report FW14048

To assist with an appropriate allocation of resources to reduce human disease, estimates have to be made of the burden of the disease on the population and this is commonly done using 'disability adjusted life years (DALYs). These are defined by WHO. One DALY can be thought of as one lost year of 'healthy' life. The sum of these DALYs across the population, or burden of disease, can then be used as a measure of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

This report is an update of a report made in 2011. It includes surveillance data for the 2013 year, updated estimates of the percentage of each disease (camplyobacteriosis, salmonellosis, listeriosis, STEC infections, yersiniosis and norovirus infection) that is due to foodborne transmission and updated life expectancy data. It is noted that in addition to changes in notification rates, changes in the age distribution of STEC cases and in the estimated foodborne proportions of STECs have had an effect on the DALY values.

The report notes that the construction of the model used in the estimates can have a profound effect on the outcome and examples of where this may be significant are noted. In particular the report provides information on comparable work in other countries. A major factor influencing DALYs is the incorporation of sequelae into the model. There is a possibility that models based on data from other countries, may not be accurate for New Zealand. However the authors of the report are of the opinion that the DALY approach is a useful mechanism for ranking the risk from these foodborne illnesses. Nevertheless, calculations made for Norovirus are severely constrained in that Norovirus infections are not notifiable in New Zealand, unlike other foodborne illnesses, although institutionally based outbreaks may be notified. Two approaches have been taken to overcome this information gap – apply a multiplier to the notified outbreaks reported in New Zealand or use UK data and apply to the New Zealand population. This gives very different outcomes with regards to the ranking of this illness making it highest ranked when the population rate calculation is applied but lower that camplyobacteriosis, listeriosis and STEC when the rates ratio is applied.

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Client Report FW14048

by

Peter Cressey
Dr Rob Lake

Dr Stephen On
Chief Scientist, Food and Water

Dr Rob Lake
Project Leader

Dr Beverley Horn
Peer Reviewer

Institute of Environmental Science & Research Limited
Christchurch Science Centre
Location address: 27 Creyke Road, Ilam, Christchurch
Postal address: P O Box 29 181, Christchurch, New Zealand
Website: www.esr.cri.nz

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Peter Cressey
Dr Rob Lake

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SUMMARY

The burden of foodborne disease in New Zealand has previously been determined for selected bacterial and viral pathogens. Burden was measured in terms of disability adjusted life years (DALY). DALY estimates were determined for campylobacteriosis, listeriosis, norovirus infection, salmonellosis, STEC infection and yersiniosis, including relevant sequelae.

The current study updates 2011 DALY estimates for the potentially foodborne diseases covered by the original New Zealand DALY report. Aspects that have changed since the 2011 estimates include:

- New Zealand surveillance data for the 2013 calendar year.
- Updated estimates of the percentage of each disease that is due to foodborne transmission, from an expert elicitation in 2013.
- Updated life expectancy estimates for the New Zealand population (2010-2012).

Of the six potentially foodborne microbial diseases examined in the current exercise the highest ranked issue, according to the DALY approach is norovirus infection (if the total number of cases is estimated using population rates), followed by campylobacteriosis, listeriosis, STEC infection, salmonellosis, and yersiniosis. If the total number of norovirus infection cases is calculated using rate ratios, rather than population rates, then the DALY estimate for this disease would be less than those for campylobacteriosis, listeriosis and STEC infection. The high ranking of norovirus infection is due to the large number of cases estimated. *Campylobacter* ranks highly due to its high incidence, but also because of the range and seriousness of its sequelae.

Changes in DALY estimates from 2011 to 2013 mainly reflect changes in notifications of the diseases. In addition, changes in the age distribution of STEC infection cases have affected the predicted incidence of sequelae (haemolytic uraemic syndrome (HUS) and end-stage renal disease (ESRD) and associated DALYs. A substantial decrease in the estimated foodborne proportion for STEC infection has reduced the DALY estimates.

Estimates for different organisms vary widely in their degree of associated uncertainty. For example, the model used to calculate DALYs associated with STEC infection generates a 95th percentile interval for the total number of gastroenteritis cases that spans three orders of magnitude, while the equivalent interval for campylobacterosis covers less than one order of magnitude.

Decisions made in the construction of the model can have major impacts on the final DALY value. For STEC infection, 90% of the DALY estimate is due to the long term sequelae that can result from infection (HUS and ESRD). While the evidence used to extrapolate from reported STEC infection cases to unreported cases and to sequelae is the best currently available, in most cases it is not New Zealand specific and it is possible that patterns of illness in New Zealand may be different to those observed overseas. For example, the model estimates a mean incidence of 82 cases per year of HUS due to STEC infection, while in the 2013 year a total of only 50 cases of HUS were reported to be hospitalised in New Zealand.

Despite these issues, the DALY approach provides a useful mechanism for assimilating a huge amount of information on infectious intestinal diseases, that would otherwise not be comparable, to produce a single ranking metric suitable as an input to risk prioritisation.

International developments in estimation of the burden of foodborne disease do not suggest that changes to the methodology currently used in New Zealand are required. However, of the sequelae included in the current DALY model, there are some questions as to whether there is a causative relationship between bacterial infections and inflammatory bowel disease.

1 INTRODUCTION

This report contributes to an on-going project to rank the risks associated with enteric pathogens in food available in New Zealand. A common risk ranking approach is to develop burden of disease estimates, measured in disability adjusted life years (DALY). DALY estimates represent the burden of illness on individuals, in terms of quality of life and are a measure of the intangible cost/burden of illness, expressed in non-monetary units. This report updates previous estimates for selected microbial diseases and considers international developments in methodology.

1.1 Previous Studies

During 2006-2007 initial estimates for the burden of foodborne disease in New Zealand were derived (Cressey and Lake, 2007). Methodology used drew heavily on previous work carried out in the Netherlands (Havelaar *et al.*, 2000; Havelaar *et al.*, 2004; Kemmeren *et al.*, 2006). These estimates used the DALY as the metric. This study was followed by a cost of illness study, using a monetary metric for estimation of the tangible direct and indirect medical costs of foodborne disease (Cressey and Lake, 2008).

Three main components are required to estimate the burden of foodborne disease using the DALY metric; estimates of the total incidence of specific potentially foodborne diseases and their sequelae, disability weights to enable morbidity to be placed on an equivalent scale to mortality, and estimates of the proportion of cases of disease that may be due to foodborne transmission. There have been developments in all of these areas in recent years and projects have been carried out to assess the impact of these developments.

Disability weights specific to diarrhoeal disease caused by foodborne pathogens were derived in the Netherlands (Haagsma *et al.*, 2008a; Haagsma *et al.*, 2009). Revised estimates of the burden of foodborne disease in New Zealand were derived to assess the impact of these novel disability weights (Cressey and Lake, 2009).

In 2011, a US study proposed a novel set of multipliers, used to scale disease cases observed through surveillance (notifications, outbreak cases) to total cases in the community (Scallan *et al.*, 2011a; Scallan *et al.*, 2011b). The multipliers were novel in including consideration of under-diagnosis separately for mild and severe cases of the disease. These multipliers and the approach used in the US study were applied to New Zealand data, to provide estimates of the total incidence of foodborne disease in New Zealand caused by microbiological pathogens (Cressey and Lake, 2011).

An update of DALY estimates for the burden of foodborne disease in New Zealand was carried out, using surveillance data from the 2011 year and considering the impact of a range of factors (Cressey, 2012), included novel disability weights, US multipliers, alternative multipliers from the second British infectious intestinal disease (IID2) study (Tam *et al.*, 2012) and alternative approaches to campylobacteriosis attribution, using information from the Manawatu enhanced surveillance project (French, 2008; 2009; 2012).

New Zealand estimates of the proportion of certain potentially foodborne microbial diseases that are due to foodborne transmission were originally derived through an expert elicitation

process in 2005 (Cressey and Lake, 2005; Lake *et al.*, 2010). Following a review of available methods (Cressey and Lake, 2012), expert elicitation was carried out in 2013, to update estimates of foodborne proportions (Cressey and Lake, 2013).

1.2 Disability-Adjusted Life Years (DALYs)

Disability adjusted life years (DALYs) were originally developed by the World Health Organization for the Global Burden of Disease Study (Murray and Lopez, 1997). The fundamental calculation for DALYs is:

$$DALY = YLL + YLD$$

YLL is the number of years of life lost due to mortality and YLD is the number of years lived with disability. For each disease, a set of health outcomes are defined. For microbiological foodborne pathogens, the initial health outcome is usually acute gastrointestinal disease, of variable severity, and possible mortality. Secondary health outcomes (sequelae) resulting from the initial infection may occur, and may also contribute to mortality.

YLL is calculated by accumulation over all health outcomes (*i*), of the number of fatal cases (*n*) due to the health outcome (*i*) multiplied by the standard life expectancy (*e*) at the age of death.

$$YLL = \sum_i n_i \times e_i$$

YLD is calculated by accumulation, over all health outcomes (*i*), of the product of the number of cases (*n*), the average duration (*t*) and the disability weight (*dw*) of the specific outcome. The disability weights are in the range zero to one, with the disability weight for death being equal to one. It should be noted that the calculation for YLL above implicitly includes the disability weight for mortality of one.

$$YLD = \sum_i n_i \times t_i \times dw_i$$

In some cases, disability weights have been derived on an 'annualised' basis and if these disability weights are used there is no need for the duration term in the YLD calculation, as the duration of disease is implicit in the derivation of the disability weight (Haagsma *et al.*, 2008a).

DALYs may be calculated using a prevalence approach which estimates the current burden of disease in a population, considering previous events. However, the more common approach is to use incidence i.e. both current and future health outcomes are included. Future outcomes include sequelae and mortality resulting from the initial disease within a defined time period. The incidence of sequelae and mortality may be estimated from transition probabilities between the initial disease and subsequent health states.

The DALY estimates for New Zealand in 2013 have been derived using the incidence approach, but the incidence of sequelae and mortality in 2013 and future years has been based on a variety of historical data.

Estimation of DALYs for potentially foodborne microbial diseases in New Zealand has been carried out by deriving estimates of the number of cases from the number of notified or outbreak cases from national surveillance, scaled by a multiplier, to account for cases that do not come to the attention of the national surveillance system. A discussion of the various inputs to the DALY calculation is included in the following sections.

1.2.1 Surveillance data

Estimates of the incidence of illness should be indexed to measureable quantities. For potentially foodborne microbial diseases, cases may be identified and measured when they interact with the public health system. In New Zealand there are two main systems that collect information on these interactions:

- Notification data are recorded using a web-based application (EpiSurv) available to staff at each of the 20 public health units (PHUs) in New Zealand. The EpiSurv database is maintained and developed by the Institute of Environmental Science and Research (ESR), who are also responsible for the collation, analysis and reporting of disease notifications on behalf of the Ministry of Health (MoH). EpiSurv also collects information on outcomes; whether the case is hospitalised and whether they died.
- MoH collates national data on patients admitted and discharged from publicly funded hospitals. These data are stored as part of the National Minimum Dataset (NMDS). Cases are assigned disease codes using the tenth revision of the International Classification of Diseases (ICD-10) coding system (World Health Organization, 2010). Up to 99 diagnostic, procedure, and accident codes may be assigned to each admission. The first of these is the principal or primary diagnosis, which is the condition that actually led to admission. This may differ from the underlying diagnosis.

1.2.2 Multipliers

'Multipliers' refers to factors that are used to scale up from known numbers of disease cases (notifications) to the total number of disease cases occurring in the community. The total number of disease cases will include notified cases, cases that present to the medical system but are not notified and cases that do not present to the medical system. Multipliers used for the original New Zealand DALY estimates were estimated from epidemiological information from a range of sources (Cressey and Lake, 2007). Two recent studies; one in the US (Scallan *et al.*, 2011a; Scallan *et al.*, 2011b) and one in Great Britain (Tam *et al.*, 2012), have used very different approaches to derive disease multipliers. The utility of these approaches for estimating the incidence of foodborne disease in New Zealand has been examined (Cressey and Lake, 2011). It was felt that the British study may provide more relevant multipliers for New Zealand, due to known similarities in the notification and health systems of the two countries.

The second Infectious Intestinal Disease (IID2) study in Britain from 2008-2009 examined a community cohort and a general practitioner (GP) cohort to determine rates of disease and ratios between notified cases and total community cases, and notified cases and GP presenting cases. Diseases caused by ten enteric pathogens were included (*Clostridium perfringens*, *Campylobacter*, *Salmonella*, *E. coli* O157, *Cryptosporidium*, *Giardia*, adenovirus, astrovirus, norovirus and rotavirus) (Tam *et al.*, 2012).

1.2.3 Disability weights

The disability weight is a measure of the valuation placed on a particular health state and is an indicator of the perceived severity of that health state by the group used to derive the disability weight.

Disability weights are determined by eliciting health state valuations from a cohort of expert or lay individuals using one or more valuation techniques. Information on the health states are presented to participants in a standardised format. This format will include information on the symptoms of the illness, but may or may not consider its (variable) duration. An alternative is to explicitly present the typical duration of illness as part of the development of disability weight.

There are no New Zealand specific disability weightings available for foodborne disease outcomes. The Ministry of Health estimate of the burden of disease and injury in New Zealand (Ministry of Health, 2013) used disability weights from the 2010 Global Burden of Disease study (Murray *et al.*, 2012a), with some minor local adjustments based on expert opinion.

In the absence of health state specific disability weights, disability weights used in earlier studies of the burden of foodborne illness were often derived from those for diseases that were considered by the researchers to be approximately equivalent (Cressey and Lake, 2007; Kemmeren *et al.*, 2006). However, work has been carried out in the Netherlands to derive disability weights specifically for health states associated with foodborne diseases (Haagsma *et al.*, 2008a). These disability weights were used in previous DALY estimates for foodborne disease in New Zealand (Cressey and Lake, 2009; Cressey, 2012).

The revised Dutch disability weights followed a classical approach, using annual profiles and defined duration (Essink-Bot and Bonsel, 2002; Haagsma *et al.*, 2008a). These disability weights used two valuation techniques (Haagsma *et al.*, 2008a; Krabbe *et al.*, 1997); Visual Analogue Scale (VAS) and Time Trade Off (TTO). The Dutch adopted a novel approach by defining a relevance criterion; the proportion of respondents who were not prepared to trade off any time to avoid the particular health state (Haagsma *et al.*, 2008a). If more than half the respondents chose this option, then a zero disability weight was applied.

1.2.4 Attribution

While all of the diseases included in this report may potentially occur due to the presence of the causative organism in food, other routes of transmission may contribute. For example, salmonellosis may occur in humans due to direct contact with animal faecal material in a farm or processing environment. Estimates of the proportion of selected microbial diseases

that are transmitted to humans by food in New Zealand have been derived, and subsequently updated, from an expert elicitation process (Cressey and Lake, 2005; 2013).

1.3 Current Study

The current study aims to provide updated DALY estimates for the potentially foodborne diseases covered by the original New Zealand DALY report (Cressey and Lake, 2007) and subsequent updates (Cressey, 2012). Aspects of the estimation specifically updated include:

- New Zealand surveillance data for the 2013 calendar year (ESR, 2014a; b; Horn *et al.*, 2014).
- Novel estimates of the percentage of each disease that is due to foodborne transmission, from expert elicitation (Cressey and Lake, 2013).
- Updated life expectancy estimates for the New Zealand population (2010-2012) (Statistics New Zealand, 2013).

In addition this study summarised recent international activity related to estimation of the burden of foodborne disease. Implications and opportunities for New Zealand estimates are discussed.

2 DALY ESTIMATES: GENERAL CONSIDERATIONS

For this project, development of DALY estimates was carried out for:

- Campylobacteriosis
- Salmonellosis
- Listeriosis (invasive, perinatal and non-perinatal)
- Shiga-toxin producing *Escherichia coli* (STEC) infection
- Yersiniosis
- Norovirus infection

Attribution studies, mainly conducted by expert elicitation, carried out in New Zealand and overseas have consistently identified that a significant proportion of these illnesses are caused by foodborne transmission of the pathogens (30-90+ %) (Adak *et al.*, 2002; Cressey and Lake, 2005; 2013; Hall and Kirk, 2005; Havelaar *et al.*, 2008; Scallan *et al.*, 2011b; Vally *et al.*, 2014).

The following sections detail the source of various inputs to the DALY calculation and how they have been treated in the current study.

The DALY estimates were calculated by developing a model using @RISK software (Palisade Corporation). For many of the factors needed for the calculations there were differing data sources or methods of estimation. Distributions were used to describe the uncertainty in input parameters.

2.1 Surveillance Data

The intention in developing these estimates was to describe the burden of illness using the most recent data. Notification and hospitalisation data, from EpiSurv and NMDS respectively, were from the 2013 calendar year (ESR, 2014a; Horn *et al.*, 2014).

DALY estimates can be strongly affected by rare events amongst the New Zealand population, such as disease-specific fatalities. Whether or not deaths had occurred due to a particular illness in a specific year could change the estimates considerably. The approach taken for estimating case fatality rates due to a particular disease was to generate distributions that described the incidence of such outcomes over a decade period (2004-2013). Data were taken from EpiSurv.

The age profile of fatal cases of microbial diseases was also updated from that used in previous studies. Fatal cases were included in this analysis if it was considered that the microbial disease was the cause of death, rather than a comorbid factor. Data were taken from EpiSurv.

Deaths due to norovirus infection are not specifically recorded in EpiSurv case reports, but are captured as a component of outbreak reports. The age profile of fatal norovirus cases was taken to be equivalent to that of fatal cases of acute gastroenteritis. As most of these fatalities involve the very old (>80 years of age) and comorbidity is very common in this age group, the criterion of only considering cases where the microbial disease was the cause of death

was not applied. In other words, for some of these cases, acute gastroenteritis would not have been recorded as the primary cause of death.

2.2 Outcomes

2.2.1 Acute gastrointestinal illness

The principal outcome for the microbial diseases under consideration (except listeriosis) is acute gastrointestinal illness (AGI), with varying degrees of severity. The illness is usually self-limiting, i.e. people recover by themselves, and any treatment is usually limited to oral rehydration solutions (ORS), pain killers, or anti-diarrhoea medicines. A New Zealand study found that that approximately 10% of people with acute gastrointestinal illness reported using anti-diarrhoea medicines (Adlam *et al.*, 2007). Patients may obtain these as over-the-counter medicines, or else from a visit to a health professional, usually a general practitioner (GP). In more severe cases, a person may be hospitalised and occasionally the illness may result in death.

Although *Listeria monocytogenes* infection may cause a non-invasive febrile gastroenteritis, there are no reliable data on the incidence and severity of this disease, and this project only considered the invasive form of the infection.

Four outcomes of AGI can be defined:

- Self-limiting – recover by themselves, do not visit GP (Community cases)
- Visit a GP and recover (GP cases)
- Hospitalised and recover (Hospitalised cases)
- Death

In this study it was assumed that cases who were hospitalised would have previously presented to a GP. This was also the approach taken in the Dutch study (Kemmeren *et al.*, 2006).

For some illnesses, further categories of AGI outcome may be needed. For example, for STEC infection, AGI with or without bloody diarrhoea may occur.

2.2.2 Sequelae

For a small proportion of cases with AGI, longer-term illnesses (sequelae) may follow the initial infection. These sequelae result in a range of disabilities and may also result in death. In some cases, the sequelae of a microbial disease may be an identified risk factor for subsequent disease. For example, inflammatory bowel disease (IBD), a potential sequel to campylobacteriosis and salmonellosis, has been associated with an increased risk of developing bowel cancer (Ekbom *et al.*, 1990). However, the current study follows the approach of Kemmeren *et al*. (2006) in only including diseases that are recognised as direct sequelae to the microbial disease.

An increased risk of developing irritable bowel syndrome has been associated with gastroenteritis caused by a range or bacterial and viral pathogens (Haagsma *et al.*, 2010;

Thabane *et al.*, 2007). Post-infectious IBS (PI-IBS) has been reported to occur in up to 15% of cases of some gastrointestinal diseases (Haagsma *et al.*, 2009). Diseases included in the current study that have been associated with PI-IBS include campylobacteriosis, salmonellosis, STEC infection and norovirus infection. While associations between gastrointestinal disease and PI-IBS have been identified, the evidence is still insufficient to establish a causal relationship and PI-IBS has not been included in the calculations for the current study. This also means that the scope of the current study maintains consistency with previous burden of foodborne disease estimates for New Zealand (Cressey and Lake, 2007; Cressey, 2012) that did not include PI-IBS as a sequel to gastrointestinal disease.

The specific outcomes included in the DALY estimates for each illness are defined in the following sections. In general, these follow the approach used by Kemmeren *et al*. (2006) and are consistent with the approach used for previous burden of foodborne disease studies for New Zealand.

2.2.3 Campylobacteriosis

The outcomes are:

AGI:

- AGI (do not visit a GP and recover)
- AGI (visit a GP and recover)
- AGI (hospitalised and recover)
- AGI (death)

Sequelae:

- Guillain-Barré Syndrome (GBS) (subcategories of mild, severe, and fatal)
- Reactive arthritis (ReA) (subcategories of no GP visit, GP visit, and hospitalised)
- IBD (no subcategories)

IBD is a collective term used to describe a group of chronic diseases of the bowel. The two most common IBDs are Crohn's disease (CD) and ulcerative colitis (UC). Estimates of the number of cases of IBD made in this study are based on the study of Gearry *et al*. (2006), which classified cases of IBD as either Crohn's disease, ulcerative colitis or indeterminate colitis.

2.2.4 Salmonellosis

The outcomes are:

AGI:

- AGI (do not visit a GP and recover)
- AGI (visit a GP and recover)
- AGI (hospitalised and recover)
- AGI (death)

Sequelae:

- ReA (subcategories of no GP visit, GP visit, and hospitalised)
- IBD (no subcategories)

2.2.5 Listeriosis

A review of the literature for the Netherlands study (Kemmeren *et al.*, 2006) indicated that the adverse outcomes for the foetus of *Listeria* infection in the mother were:

- Intrauterine death (abortion, stillbirth)
- Liveborn infected: severe systemic infection, sepsis, pneumonia, central nervous system (CNS) infection (meningitis)

Death of the foetus as a consequence of listeriosis is included in the burden of disease estimates as YLL, as is neonatal mortality.

For *Listeria* infection in persons other than pregnant women a wider range of outcomes were considered by the Dutch study:

- Visit a GP and recover
- Visit a GP and hospitalised, experience gastroenteritis and recover
- Visit a GP and hospitalised with septicaemia and recover
- Visit a GP and hospitalised with septicaemia and die
- Visit a GP and hospitalised with meningitis and recover
- Visit a GP and hospitalised with meningitis and die
- Visit a GP and hospitalised with meningitis and experience long term neurological sequelae
- Visit a GP and hospitalised and die

These outcomes were condensed into the following categories:

- Sepsis
- Meningitis
- Gastroenteritis
- Pneumonia
- Long term neurological sequelae
- Death

2.2.6 STEC infection

A complex set of outcomes were considered by the Dutch study for the consequences of STEC infection. These were condensed in the analysis to the following categories:

- AGI with non-bloody diarrhoea (with or without presentation to a GP)
- AGI with bloody diarrhoea (with or without presentation to a GP)
- AGI (hospitalised and recover)
- AGI (death)
- Haemolytic uraemic syndrome (HUS)

- End Stage Renal Disease (ESRD), subsequent to HUS, including disability and/or death subsequent to dialysis, transplantation and graft rejection

2.2.7 Yersiniosis

This illness was not considered in the Dutch study. It was considered that the same AGI outcomes will apply, as for other common enteric diseases such as campylobacteriosis and salmonellosis. A range of complications for infection with *Yersinia enterocolitica* were reported from a nine year study in the Netherlands (Stolk-Engelaar and Hoogkamp-Korstanje, 1996). These included enteritis, enteritis with complications (including septicaemia, lymphadenitis, arthritis, erythema nodosum, and disturbed liver function), appendicular syndrome, ileitis, and colitis.

The outcomes selected for this study are:

AGI:

- AGI (do not visit a GP and recover)
- AGI (visit a GP and recover)
- AGI (hospitalised and recover)
- AGI (death)

Sequelae:

Although there are a range of complications resulting from yersiniosis, most of these appear to be related to the initial infection and are not strictly sequelae. As an interim position, it was decided to only estimate reactive arthritis as a sequel contributing to the DALY burden, due to a lack of information on the incidence and severity of other sequelae. This is consistent with the findings of a recent study (Rosner *et al.*, 2013) and is also in agreement with the symptoms described in a Dutch publication on diet and safe food which incorporates the Campylobacter Risk Management and Assessment (CARMA) project (in Appendix 5) (van Kreijl *et al.*, 2006).

- ReA

2.2.8 Norovirus infection

Sequelae are not considered to occur following norovirus infection. The outcomes are simply those for AGI.

AGI:

- AGI (do not visit a GP and recover)
- AGI (visit a GP and recover)
- AGI (hospitalised and recover)
- AGI (death)

2.3 Multipliers

AGI and its consequences can be organised into a pyramid that builds up from a base of all cases (reported and non-reported) to the small number of cases resulting in notification:

- **All cases (GP visitors and community cases)**
- **Cases who visit a GP**
- Cases who visit a GP and who are requested to supply a sample
- Cases who visit a GP and supply a faecal sample
- Laboratory confirmed cases
- Notifications

The DALY method requires estimation of the number of cases at each of the bolded levels. However, the primary available dataset concerns notifications. Consequently, there is a need to apply scaling factors (multipliers) to the number of notifications to estimate the number of cases attending a GP and another scaling factor to estimate the total number of cases.

Wherever possible multipliers were 'borrowed' from the British IID2 study (Tam *et al.*, 2012). However, this study did not derive multipliers for listeriosis or yersiniosis. For these two diseases the multipliers derived for the original study on the burden of foodborne disease in New Zealand were used (Cressey and Lake, 2007).

2.3.1 Longitudinal study of infectious disease in the UK (IID2 study)

IID2 calculated rate ratios (multipliers) by assuming that the rates in the community, presenting to GPs and reporting to national surveillance came from lognormal distributions with the observed mean and standard deviation (Tam *et al.*, 2012). The rate ratio was then calculated by simulation modelling of 'draws' from these lognormal distributions. The median, 2.5th and 97.5th percentiles of the resultant distribution were reported. For the current study, these percentiles were used to define a lognormal distribution for the rate ratio or the rate. The rates and rate ratios relevant to the current study are summarised in Table 1.

Table 1: Rates and rate ratios of selected potentially foodborne disease from the IID2 study

Organism	**Rate (cases per 1000 person-years, 95% CI)** **Rate ratio to national surveillance (95% CI)**		
	Reporting to National surveillance	Presenting to general practice	Community
Campylobacter	0.997 (0.989-1.005) 1.0	1.3 (0.9-1.8) 1.3 (0.9-1.8)	9.3 (6.0-14.3) 9.3 (6.0-14.4)
E. coli O157 VTEC	0.042 (0.040-0.043) 1.0	0.0 (0.0-0.1) -	0.3 (0.0-4.3) 7.4 (0.5-104.4)
Salmonella	0.133 (0.130-0.136) 1.0	0.2 (0.1-0.4) 1.4 (0.6-3.3)	0.6 (0.2-2.4) 4.7 (1.2-18.2)
Norovirus	0.164 (0.110-0.200) 1.0	2.1 (1.4-3.0) 12.7 (8.8-18.3)	47.0 (39.1-56.5) 287.6 (239.1-346)

The most obvious change between IID1 and IID2 is for norovirus, where rates have increased while rate ratios have decreased (Tam *et al.*, 2012; Wheeler *et al.*, 1999). This is most marked for the total incidence of norovirus infection (community incidence), where the community rate has increased from 12.5 cases per 1000 person-years to 47.0 cases per 1000 person-years, while the rate ratio between community and national surveillance rates has decreased from 1562 to 288. The IID2 report notes that most notified norovirus infections are from outbreaks in hospitals and institutional settings and the rate **ratio** from national surveillance to community for sporadic norovirus cases is likely to be higher than reported in the IID2 study.

Norovirus infections are not notifiable in New Zealand, although norovirus cases may be notified if they are believed to be part of a common-source outbreak or if they involve a person from a high risk category. As it is not clear whether the base of norovirus notifications in New Zealand and the UK are at all comparable, two approaches were taken to calculating norovirus infection incidence:

- Case numbers were derived by applying rate ratio multipliers to the number of norovirus notifications in New Zealand.
- The rates for norovirus cases presenting to a GP and present in the community, from the IID2 study, were applied to the New Zealand population (2013 midpoint).

2.4 Life expectancy

Statistics New Zealand provides tables that show life expectancy for males and females at ages up to 105 years, for the reference years 2010-2012 (Statistics New Zealand, 2013). These were used for calculations in the current DALY estimates, particularly for estimating the years of life lost through premature death.

2.5 Disability Weights

The determination of novel disability weights for the Netherlands used Visual Analogue Scale (VAS) and Time Trade Off (TTO) to elicit health state valuations from a cohort of 115 lay people (Haagsma *et al.*, 2008a). VAS values were converted to TTO equivalents using the logarithmic transformation of Krabbe *et al.* (1997). For some mild conditions participants were not prepared to trade off any time at full health to avoid the condition. This information was used to define a 'relevance criterion' – if greater than 50% of participants were not prepared to trade any time, then the health state was assigned a zero disability weight (Haagsma *et al.*, 2008a; Haagsma *et al.*, 2008b). Mean VAS and TTO values, TTO equivalents calculated from VAS and relevance criteria for foodborne disease health states are summarised in Table 2.

As participants were asked to "trade off" a portion of one year of full health, for illness with a duration of less than one year, duration is not further considered in the DALY calculation. However, for illnesses lasting more than one year (e.g. end-stage renal disease), the duration (based on life expectancy for life-long illnesses) is included in the calculation, in terms of the number of periods of one year.

While there is evidence that the ranking of the severity of different health states is reasonably consistent across different countries, elicitation panels and study methods (Essink-Bot *et al.*, 2002; Ustun *et al.*, 1999), the application of a relevance criterion is novel and it is not

currently known whether the societal norms expressed are 'transportable' from the Netherlands to New Zealand.

Three conditions did not meet the relevance criterion; mild gastroenteritis for 1 or 5 days and mild reactive arthritis for one week. For the current study, DALY estimates were calculated using the TTO mean values in Table 2, without application of the relevance criterion. The impact of the relevance criterion on DALY estimates for potentially foodborne microbial disease in New Zealand has been assessed previously (Cressey and Lake, 2009; Cressey, 2012), but has not been applied in the current study.

Table 2: Health state valuation data (Haagsma *et al.*, 2008a)

State	VAS mean	TTO transformed[1]	TTO median	TTO mean[2]	Relevance Criterion (%TTO=0)
Gastroenteritis, mild, 1 day	0.036	0.0004	0	0.002	88[3]
Gastroenteritis, mild, 5 days	0.102	0.004	0	0.01	60[3]
Gastroenteritis, moderate, 10 days	0.13	0.008	0.005	0.015	26
Gastroenteritis, severe, 7 days	0.231	0.031	0.008	0.025	25
Gastroenteritis, severe, 14 days	0.295	0.055	0.011	0.041	17
Gastroenteritis, chronic, 6 months	0.368	0.093	0.058	0.099	8
GBS, F1, whole year	0.185	0.018	0.008	0.044	40
GBS, F2, whole year	0.42	0.127	0.077	0.137	7
GBS, F3, whole year	0.545	0.236	0.153	0.215	2
GBS, F4, whole year	0.7	0.428	0.252	0.367	2
GBS, F5, whole year	0.722	0.460	0.403	0.46	0
ReA, mild, 1 week	0.107	0.005	0	0.004	68[3]
ReA, mild, 6 weeks	0.197	0.021	0.011	0.023	25
ReA, moderate, 6 months	0.447	0.147	0.058	0.115	8
ReA, severe, 6 months	0.503	0.195	0.153	0.186	4
HUS, moderate, 1 month	0.279	0.048	0.022	0.056	13
HUS, severe, 1 month	0.481	0.175	0.038	0.11	0
Renal failure, whole year	0.628	0.330	0.252	0.328	0
Crohn's disease, 6 months	0.347	0.080	0.067	0.105	4
Ulcerative colitis, 6 months	0.492	0.185	0.115	0.154	7

VAS: Visual Analogue Scale, TTO: Time Trade Off
GBS: Guillain-Barré Syndrome, ReA: reactive arthritis, HUS: haemolytic uraemic syndrome
[1] Calculated from VAS using the logarithmic transformation method of Krabbe *et al*. (1997)
[2] Used for DALY estimates in this report
[3] For these health states more than 50% of respondents were not prepared to trade off any time and in the Dutch study these health states were assigned a zero disability weight (Haagsma *et al.*, 2008a)

The complete list of disability weights used for the current update of the burden of foodborne disease in New Zealand and their source is summarised in Table 3.

Table 3: Disability weights used in the current study and their source

Health state	Disability weight	Source
AGI (do not visit a GP and recover)	0.01	(Haagsma et al., 2008a) Gastroenteritis, mild, 5 days
AGI (visit a GP and recover)	0.015	(Haagsma et al., 2008a) Gastroenteritis, moderate, 10 days
AGI (hospitalised and recover)	0.041	(Haagsma et al., 2008a) Gastroenteritis, severe, 14 days
GBS clinical mild	0.035	(Mangen *et al.*, 2004) Mild GBS first year, scaled using novel DWs for F1 and F2 health states from (Haagsma *et al.*, 2008a)[1]
GBS clinical severe (case <50 years)	0.111	(Mangen *et al.*, 2004) Severe GBS first year for cases <50 years, scaled using novel DWs for F3-F5 health states from (Haagsma *et al.*, 2008a)[1]
GBS clinical severe (case >50 years)	0.144	(Mangen *et al.*, 2004) Severe GBS first year for cases >50 years, scaled using novel DWs for F3-F5 health states from (Haagsma *et al.*, 2008a)[1]
GBS residual mild	0.0119	(Mangen *et al.*, 2004) Mild GBS subsequent years, scaled using novel DWs for F1 and F2 health states from (Haagsma *et al.*, 2008a)[1]
GBS residual severe (case <50 years)	0.071	(Mangen *et al.*, 2004) Severe GBS subsequent years for cases <50 years, scaled using novel DWs for F3-F5 health states from (Haagsma *et al.*, 2008a)[1]
GBS residual severe (case >50 years)	0.096	(Mangen *et al.*, 2004) Severe GBS subsequent years for cases >50 years, scaled using novel DWs for F3-F5 health states from (Haagsma *et al.*, 2008a)[1]
ReA (no GP visit)	0.023	(Haagsma et al., 2008a) ReA, mild, 6 weeks
ReA (GP visit)	0.115	(Haagsma et al., 2008a) ReA, moderate, 6 months
ReA (hospitalised)	0.186	(Haagsma et al., 2008a) ReA, severe, 6 months
IBD	0.12	(Haagsma et al., 2008a) Crohn's disease and ulcerative colitis, mean weighted for relative rates of these diseases reported in New Zealand (Gearry *et al.*, 2006)
Listeriosis (sepsis)	0.93	(Kemmeren *et al.*, 2006) Sepsis
Listeriosis (meningitis)	0.32	(Kemmeren *et al.*, 2006) Meningitis
Listeriosis (gastroenteritis)	0.393	(Kemmeren *et al.*, 2006) Gastroenteritis, visit GP/hospitalised
Listeriosis (pneumonia)	0.04	(Kemmeren *et al.*, 2006) Pneumonia
Listeriosis (long term neurological sequelae)	0.25	(Kemmeren *et al.*, 2006) Neurological disorders
AGI (STEC, bloody diarrhoea, without GP visit)	0.015	(Haagsma et al., 2008a) Gastroenteritis, moderate, 10 days
AGI (STEC, bloody diarrhoea, without GP visit)	0.025	(Haagsma et al., 2008a) Gastroenteritis, severe, 7 days
HUS	0.056	(Haagsma et al., 2008a) HUS, moderate, 1 month
ESRD	0.328	(Haagsma et al., 2008a) Renal failure, whole year

AGI: acute gastrointestinal illness, GBS: Guillain-Barré Syndrome, ReA: reactive arthritis, IBD: inflammatory bowel disease, HUS: haemolytic uraemic syndrome, ESRD: End Stage Renal Disease, STEC: shiga-toxin producing *E. coli*, GP: general practitioner, DWs: disability weights

[1] The health states F1-F5 are a scoring scale used to describe the functional status of GBS cases, from F1 = Minor signs or symptoms of neuropathy but capable of running, to F5 = Requiring artificial ventilation

2.6 Attribution: Percentage Foodborne

The proportion of the DALY burden of illness estimates attributed to foodborne transmission of the pathogens has previously been calculated using attribution estimates provided by an expert consultation workshop conducted in May 2005 (Cressey and Lake, 2005). These

expert estimates were updated in 2013 (Cressey and Lake, 2013). Each expert's estimates of minimum, most likely, and maximum proportion of each disease that was due to foodborne transmission were treated as a Pert distribution and combined by simulation modelling. Simulation modelling was carried out using uniform weights (all experts equally expert), user-defined weights based on self-assessment of expertise, and performance-based weights derived from answers to calibration questions. Foodborne burden estimates used in the current study were derived using foodborne attribution proportions based on user-defined weights. The relevant data for the illnesses being considered are given in Table 4. The values from the earlier expert elicitation are included for comparison.

Table 4: Comparison of aggregate opinions from the 2013 and 2005 New Zealand expert elicitation studies

Pathogen	Mean aggregate estimate of the proportion of disease that is due to foodborne transmission (%) (95th percentile interval)	
	2013 (Self-assessed weighting)	2005
Campylobacter	63.8 (44.1-83.2)	56.2 (26-82)
Listeria monocytogenes	87.8 (57.9-98.5)	85.0 (48-100)
Norovirus	32.7 (10.0-66.4)	39.2 (8-64)
Salmonella	62.1 (35.2-86.4)	59.6 (18-83)
STEC O157	29.9 (3.5-60.7)	39.5[1] (6-95)
Non-O157 STEC	34.0 (3.5-63.5)	39.5[1] (6-95)
Yersinia enterocolitica	63.2 (29.0-91.5)	56.2 (32-92)

[1] For all STEC genotypes

Comparisons between the findings of the 2013 and the 2005 expert elicitation projects need to be considered in the context of developments in research in intervening years. This is particularly apparent for campylobacteriosis. In the years immediately after the 2005 expert elicitation project was completed, substantial advances in research methodologies occurred that enabled more detailed estimates of the contribution of different animal reservoirs to *Campylobacter* infection rates. This work indicated that the contribution from poultry before 2007 was likely to have been much higher than previously considered.

Between 2006 and 2008, substantial reductions occurred in both the overall campylobacteriosis rate and the proportion attributable to poultry, largely considered to be due to implementation of interventions to reduce *Campylobacter* contamination on poultry meat. The 2013 expert elicitation findings have taken this into account, and provide an estimate of the foodborne proportion of campylobacteriosis that is consistent with current findings from source attribution research. Notably, there was better agreement between the individual experts' estimates of the foodborne proportion of campylobacteriosis than for other pathogens. This example illustrates that expert elicitation estimates reflect knowledge at a point in time, and must be interpreted as such.

It should be noted that the 2013 expert elicitation determined separate estimates of the proportion foodborne for STEC O157 and non-O157 STECs. Previous estimates of the burden of foodborne disease for New Zealand have considered these organisms as a single group (Cressey and Lake, 2007; 2009; Cressey, 2012). For the present study, a composite proportion foodborne was derived by a weighted combination of the separate estimates, with the weighting reflecting the relative proportions of cases due to O157 and non-O157 serotypes observed in 2013.

3 RESULTS AND DISCUSSION

Since the last calculation of DALYs for selected foodborne diseases in New Zealand (Cressey, 2012), three factors could contribute to a change in DALY estimates:

- Changes in the incidence of notified disease, hospitalisations or fatalities as measured by surveillance data.
- Changes in the estimates of attribution to the foodborne route of transmission.
- Update of the life expectancy tables for New Zealand.

Changes in the New Zealand population during the period 2011 to 2013 will also affect one of the methods used for estimating norovirus incidence; the method that calculates norovirus incidence as a fixed percentage of the population (population rate).

Changes in life expectancy will have only a minor effect on DALY estimates. These changes will mainly impact estimates of YLL, which contributes the lesser amount to DALYs compared to YLD. To put changes in life expectancy in perspective, the YLL for a foetal death has increased from 80.1 years to 81.2 years.

In order to examine the influence of these factors on DALY estimates, the updated estimates were compared to the old in two stages:

- Comparison of disease incidence estimates, incorporating changes in surveillance data.
- Comparison of DALY estimates, broken down by YLD and YLL, considering sensitivity to attribution changes.

3.1 Incidence of Potentially Foodborne Diseases

Estimates of disease incidence for 2011 and 2013 are included in Appendix 1.

As the multipliers used to scale the number of notified cases to the estimate total, community and GP cases are the same as those used for the 2011 DALYs update, most of the changes in disease incidence are directly related to changes in notifications.

One point is worth noting. While the estimated incidence of STEC infection has increased by approximately one-third, a much smaller increase in cases of HUS (6%) and ESRD (3%) are estimated. The risk of developing HUS (and ESRD) following a STEC infection is highest amongst young children (0-4 years). Between 2011 and 2013, the percentage of notified STEC infection cases in this age group decreased from 45% to 38% of total notified STEC infection cases. While there was a small increase in the absolute number of STEC infection notified cases in this age group (69 to 78 cases), most of the increase in notifications (154 to 207 cases) was amongst age groups with a lower risk of developing HUS. Consequently, the proportional increase in estimated HUS and ESRD cases was less than the proportional increase in STEC infection cases.

3.2 Burden of Potentially Foodborne Diseases (DALYs)

Table 5 summarises the results of the mean values for YLD, YLL, DALYs and foodborne DALYs for simulations run for the DALY model in @Risk (10,000 iterations) and compares them to the equivalent values estimated for the 2011 year (Cressey, 2012).

Table 5: Updated mean DALY estimates for selected foodborne diseases in New Zealand

Disease State	YLL		YLD		DALYs		Foodborne DALYs	
	2011	2013	2011	2013	2011	2013	2011	2013
Campylobacteriosis and sequelae								
GE	9	4	705	726	714	730		
GBS	21	21	80	74	101	95		
ReA			30	31	30	31		
IBD			112	120	112	120		
Total	**30**	**25**	**927**	**951**	**957**	**976**	**540**	**622**
Listeriosis								
Total	**180**	**207**	**8**	**5**	**188**	**212**	**160**	**179**
Norovirus infection (Rate ratios)								
Total	**91**	**33**	**219**	**220**	**310**	**253**	**122**	**87**
Norovirus infection (Population rates)								
Total	**91**	**33**	**2135**	**2162**	**2226**	**2195**	**873**	**758**
Salmonellosis and sequelae								
GE	15	14	77	83	92	97		
ReA			4	5	4	5		
IBD			17	19	17	19		
Total	**15**	**14**	**97**	**107**	**112**	**121**	**67**	**74**
STEC infection and sequelae								
GE	5	1	44	60	49	61		
HUS	195	193	4	5	199	198		
ESRD	95	90	162	161	257	251		
Total	**295**	**284**	**210**	**226**	**505**	**510**	**200**	**156**
Yersiniosis and sequelae								
GE	2	3	104	99	106	102		
ReA			4	4	4	4		
Total	**2**	**3**	**109**	**103**	**111**	**106**	**62**	**66**

YLL: Years of Life Lost, YLD: Years of Life Lived with Disability, DALY: Disability Adjusted Life Years

GE: gastroenteritis, GBS: Guillain-Barré Syndrome, ReA: reactive arthritis, IBD: inflammatory bowel disease, HUS: haemolytic uraemic syndrome, ESRD: End Stage Renal Disease, STEC: shiga-toxin producing *E. coli*, GP: general practitioner

Changes in the estimates of foodborne DALYs between 2011 and 2013 are mainly due to changes in the estimated incidence of disease, as outlined in Appendix 1, as would be expected, as this is the main input variable that has changed since the last update. The changes in the DALY estimates are reasonably minor for most diseases. The largest

percentage change was for norovirus infection, using a rate ratio approach (29% decrease). This was mainly due to changes in the age profile of fatal cases.

DALY estimates for campylobacteriosis increased by 15%, mainly due to an increase in the estimated foodborne proportion to this disease (14% increase). It should be noted that, while the DALY estimates were compared between 2011 and 2013, the expert elicitation studies used to estimate the foodborne proportion were carried out in 2005 and 2013, respectively.

It is of interest to note that although the notifications for STEC infection have risen quite markedly, the DALYs have decreased by 22% since 2011. Two factors contribute to this:

- The estimated proportion of STEC infection cases that are believed to be due to foodborne transmission has decreased from approximately 40% to 30%, based on expert elicitation.
- The change in the age distribution of STEC infection cases means that, while a greater number of HUS cases are estimated by the model, these cases will on average be older. For life-long or fatal outcomes this means a lesser number of years lived with disability or less years of life lost.

3.3 Ranking of Potentially Foodborne Diseases

DALY estimates are summarised and ranked in order of decreasing foodborne DALYs in Table 6.

Table 6: Mean YLD, YLL, DALYs and foodborne DALYs for potentially foodborne infectious intestinal diseases in New Zealand, 2013

Disease	YLD	YLL	DALYs	Foodborne DALYs (95^{th} percentile interval)
Norovirus infection, based on rates	2162	33	2195	758 (385-1183)
Campylobacteriosis	951	25	976	622 (439-842)
Listeriosis	5	207	212	179 (54-318)
STEC infection	226	284	510	156 (1.5-645)
Norovirus infection, based on rate ratios	220	33	253	87 (45-137)
Salmonellosis	107	14	121	74 (31-153)
Yersiniosis	103	3	106	66 (41-96)

YLL: Years of Life Lost, YLD: Years of Life Lived with Disability, DALY: Disability Adjusted Life Years

The mean ranking order in Table 6 shows one change from the mean ranking based on DALYs carried out for the 2011 year (Cressey, 2012), with the relative positions of listeriosis and STEC infection being swapped. The current analysis concludes that norovirus contributes the greatest mean burden of disease, as measured by DALYs, of the six pathogens considered. However, this is critically dependent on the multiplier (rate or rate ratio) used to calculate disease incidence.

4 INTERNATIONAL DEVELOPMENTS

While New Zealand estimates of the burden of foodborne disease are based as much as possible on New Zealand-specific data, some of the inputs to the model calculations are drawn from international studies. The following sections summarise international developments that may inform studies of the burden of foodborne disease in New Zealand.

4.1 Global Burden of Foodborne Disease Study

In September 2006, the Department of Food Safety Zoonoses and Foodborne Diseases (FOS; now renamed the Department of Food Safety and Zoonoses) at the World Health Organization (WHO) launched an initiative to estimate the Global Burden of Foodborne Diseases (FBD) at an international consultation attended by over 50 international experts (World Health Organization, 2008a). This consultation provided the strategic framework for the assessment of FBD burden and mandated WHO to establish a Foodborne Disease Burden Epidemiology Reference Group (FERG) which engages in:

- Assembling, appraising and reporting on currently existing burden of foodborne disease estimates;
- Conducting epidemiological reviews for mortality, morbidity and disability in each of the major FBD;
- Providing models for the estimation of FBD burden where data are lacking;
- Developing cause and source attribution models to estimate the proportion of diseases that are foodborne, and
- Developing user-friendly tools for burden of FBD studies at country level.

The first report from the initiative, published in 2008, described the following objectives:

- To strengthen the capacity of countries in conducting burden of foodborne disease assessments and to increase the number of countries who have undertaken a burden of foodborne disease study.
- **To provide estimates on the global burden of foodborne diseases according to age, sex and regions for a defined list of causative agents of microbial, parasitic, and chemical origin.**
- To increase awareness and commitment among Member States for the implementation of food safety standards.
- To encourage countries to use burden of foodborne disease estimates for cost-effective analyses of prevention, intervention and control measures.

At the time of publication of the current report, technical details from the FERG studies are not available. It is expected that these data will be available during the first half of 2015.

4.2 Attribution

The DALYs calculation requires an estimate of the proportion of total cases of a disease that are due to foodborne transmission (foodborne proportion). Individual studies that have derived estimates of foodborne proportions are briefly described in the sections below.

Estimates of the foodborne proportion for the microbial diseases covered by the various studies are summarised and compared in Table 7.

4.2.1 New Zealand

Updated estimates of the foodborne proportion have been obtained for microbial diseases in New Zealand through an expert elicitation process (Cressey and Lake, 2013). Estimates relevant to the current study were given in Table 4. The full range of estimates is given in Table 7, to allow comparison to other studies.

4.2.2 Australia

Expert elicitation was used to derive foodborne proportion estimates for nine microbial diseases (Vally *et al.*, 2014). Estimates were also derived for four other transmission routes: environmental (soil, air, fomites), water, person-to-person and zoonotic (animal contact).

4.2.3 Canada

A structured expert elicitation survey was used to derive estimates of the foodborne attributable proportion for nine illnesses caused by enteric pathogens in Canada (Ravel *et al.*, 2010). Cluster analysis revealed subpopulations of opinions for some pathogens.

4.2.4 United Kingdom

In an extension to the IID2 study, outbreak data for the period 2001-2008 were used to estimate the foodborne proportion for specific microbial diseases. The foodborne proportion was derived from the number of outbreak cases from foodborne outbreaks due to a particular pathogen, as a proportion of total outbreak cases due to that organism (Tam *et al.*, 2014).

Table 7: Comparison of foodborne proportions for various microbial diseases derived from New Zealand and international studies

Disease	Foodborne Proportion (%)			
	New Zealand[1]	**Australia[2]**	**Canada[2]**	**United Kingdom**
Astrovirus infection				0.0
Campylobacteriosis	63.8	76	68	50.1
Clostridium perfringens intoxication		97		86.2
Cryptosporidiosis			9	5.1
Giardiasis				16.7
Hepatitis A		12		
Listeriosis	87.8	97	84	100
Norovirus infection	32.7	17	31	2.5
Other pathogenic *E. coli*		24		
Rotavirus infection				1.4
Salmonellosis	62.1	71	80	90.4
Shigellosis		11	18	22.2
STEC infection	O157 29.9 Non-O157 34.0	55	O157 76	O157 53.1
Toxoplasmosis	27.6			
Vibrio parahaemolyticus infection	90.6		82[3]	
Yersiniosis	63.2		80	

[1] Mean of expert opinions, combined using self-assessed expertise weighting
[2] Mean values
[3] Estimate relates to *Vibrio* spp., including *V. parahaemolyticus, V. vulnificus* and *V. cholerae*

The data in Table 7 show little consistency in estimates of the foodborne proportion across the four developed countries. It is uncertain whether differences in estimates represent true differences in the foodborne proportion between different countries or differences in study methodology.

4.3 Disability Weights (DWs)

4.3.1 Global Burden of Disease Study 2010

The Global Burden of Disease Study 2010 (GBD2010) used the DALY metric to determine the global burden of 291 diseases (Murray *et al.*, 2012a; Murray *et al.*, 2012b). A component of the study was the derivations of novel DWs (Salomon, 2010; Salomon *et al.*, 2012). These DWs will be used in the Global Burden of Foodborne Disease Study, which is currently in progress (Kuchenmüller *et al.*, 2009).

GBD2010 DWs were determined from face-to-face household interviews in Bangladesh, Indonesia, Peru and Tanzania, telephone interviews in the United States and an open access web-based survey. The interviews and survey tools were structured as a series of pairwise comparisons of individuals in different health states. A critique of the methods used to determine GBD2010 DWs has recently been published (Nord, 2013).

GBD2010 used disease prevalence and DWs to calculate YLDs, in most cases without the need to specify duration of disease (Murray *et al.*, 2012a). However, for minimal disease states, such as acute diarrhoea, a duration term is required (Juanita Haagsma, Erasmus Medical Center, Rotterdam, Netherlands, personal communication).

4.3.2 Ontario Burden of Infectious Disease Study

The Ontario Burden of Infectious Disease Study (ONBOIDS) determined DWs (referred to as severity weights) using a method called Classification and Measurement System of Function Health (CLAMES) (Kwong *et al.*, 2010). The investigators used the standard gamble (SG) technique to elicit participants' preferences for sets of health states that were blinded to minimise participant biases. In the standard gamble technique, preferences for a given health state are assessed in terms of participants' willingness to undergo a specific treatment, which has a probability of either restoring them to full health or causing death. The investigators generated the scoring function by fitting these preferences scores with a log-linear model.

The severity weights are used to calculate Year-equivalents of Reduced Functioning (YERFs), which appear to be equivalent to YLDs. The YERF calculation requires the duration of the health state to be specified, as for the GBD2010 DWs for minimal disease states.

Table 8 shows DWs from GBD2010 and severity weights from the ONBOIDS relevant to foodborne disease. Earlier DWs used for estimating the burden of foodborne disease in New Zealand, that also required specification of health state duration, are included for comparison (Cressey and Lake, 2007). It should be noted that the DWs used in more recent estimates of the burden of foodborne disease in New Zealand (Cressey and Lake, 2009; Cressey, 2012) incorporate disease duration and are not comparable to the DWs from GBD2010 and ONBOIDS.

Table 8: Comparison of disability/severity weights from different sources

GBD2010		ONBOIDS		New Zealand Burden of Foodborne Disease Study (2007)[1]	
Descriptor	**Value**	**Descriptor**	**Value**	**Descriptor**	**Value**
Diarrhoea, mild	0.061	Gastroenteritis, mild	0.023	AGI (do not visit a GP and recover)	0.067
Diarrhoea, moderate	0.202	Gastroenteritis, moderate	0.041	AGI (visit a GP and recover)	0.393
Diarrhoea, severe	0.281	Gastroenteritis, severe	0.086	AGI (hospitalised and recover)	0.393
Bacterial meningitis	0.21	Bacterial meningitis	0.652	Listeriosis: Meningitis	0.32
Sepsis and other infectious disorders of the newborn	0.21	Septicaemia	0.652	Listeriosis: Sepsis	0.93
Osteoarthritis	0.023-0.171	Reactive arthritis	0.041	Reactive arthritis	0.13-0.37
Guillain-Barré syndrome	0.047	Guillain-Barré syndrome	0.132	Guillain-Barré syndrome	0.10-0.94
		Haemolytic uraemic syndrome	0.171	Haemolytic uraemic syndrome	0.90
End stage renal disease, on dialysis	0.573	End stage renal disease (dialysis)	0.260	End stage renal disease (dialysis)	0.18

GBD2010 = 2010 Global Burden of Disease study (Murray *et al.*, 2012b); ONBOIDS = Ontario Burden of Infectious Disease study (Kwong *et al.*, 2010)

[1] Disability weights used in this study were mostly derived from (Kemmeren *et al.*, 2006)

The data in Table 8 highlight the variability in DWs across different studies.

4.3.3 Reviews

A review of published DW studies has been carried out with a focus on the methodological design choices (health state and time description, panel composition, and valuation method) (Haagsma *et al.*, 2014). Most studies used a disease-specific description of the health state, a panel made up of medical experts, and non-preference-based valuation methods to derive DWs. DWs for similar health states were found to differ, particularly in the case of mild diseases, by a factor of two or more. This finding is consistent with the information presented in Table 8.

4.4 Multipliers

4.4.1 Canada

A study to determine the burden of foodborne illness in Canada for 30 specified pathogens and unspecified agents (Thomas *et al.*, 2013) largely followed the methodology used for a similar study in the United States (Scallan *et al.*, 2011a; Scallan *et al.*, 2011b). While the multipliers used to scale pathogen-specific disease estimates from notifications to total cases followed the same format as the US study, country-specific data were incorporated where possible. Table 9 summarises some of the multipliers used in the Canadian study and compares them to multipliers used in the US study and those used in the current study. It should be noted that not all multipliers are summarised here, but those of most relevance to the current New Zealand study.

Table 9: Comparison of multipliers between different burden of foodborne disease studies

Organism	Canada[1]			United States[2]			New Zealand[3]
	Under-reporting	Under-diagnosis	Total	Under-reporting	Under-diagnosis	Total	Total (mean)
Campylobacter spp.	1.1	25.2	26.8	1.0	30.3	30.3	9.5
Listeria monocytogenes	1.1	1.6	1.7	1.0	2.1	2.1	1.0
Salmonella spp.	1.1	11.9	12.7	1.0	29.3	29.3	6.0
STEC O157	1.1	18.4	20.1	1.0	26.1	26.1	18.4
Yersinia enterocolitica	1.1	36.4	39.3	1.0	122.8	122.8	18.4

[1] (Thomas *et al.*, 2013)
[2] (Scallan *et al.*, 2011b)
[3] Current study. The multipliers used in this study are derived from the British IID2 study (Tam *et al.*, 2012), except for those used for disease due to *Listeria monocytogenes* and *Yersinia enterocolitica*, which were derived in the original New Zealand DALY study (Cressey and Lake, 2007)

While multipliers derived for the Canadian study are generally markedly lower than those used in the US study, they are considerably higher than those currently used in New Zealand.

4.5 Sequelae

There is ongoing debate concerning which diseases or conditions should be considered to have resulted from an initial microbial infection or intoxication. The following sections summarise epidemiological investigations that inform this topic. Only recently published (2010-2014) studies were reviewed and summarised.

4.5.1 Reactive arthritis (ReA)

A systematic review was conducted that concluded that the weighted mean incidence of ReA following *Campylobacter*, *Salmonella* and *Shigella* infection was 9, 12 and 12 cases per 1000, respectively (Ajene *et al.*, 2013). It was also noted that, where age specific information was available, children were less likely to develop ReA following bacterial infection than adults. The current study estimates 10 and 21 cases per 1000 for ReA due to *Campylobacter* and *Salmonella*, respectively. It should be noted that the studies included in the systematic review mostly used notified cases or cases presenting to a GP as their study base. It is unknown whether incidence of ReA is similar in cases of *Campylobacter* and *Salmonella* infection that do not attend a GP and are not notified.

Patients with campylobacteriosis (n = 105) were assessed for single nucleotide polymorphisms (SNPs) in inflammatory cytokine genes (Nielsen *et al.*, 2012). The population distribution of the gene variants was also assessed in healthy controls (n = 192). Patients were then followed up six months later. ReA had developed in 15 patients and was found to be strongly associated with certain SNPs. For example, 32% of campylobacteriosis cases with the INFG(+874 T/T) variant developed ReA, while none of the campylobacteriosis

cases with the INFG(+874 A/A) variant developed ReA. The genotype INFG(+874 A/A) was found significantly less frequently in cases than controls, while there was no significant difference in the frequency of all other types in cases and controls.

A multi-centre cross-sectional study of culture-positive campylobacteriosis cases was carried out in Finland in 2002 (Schönberg-Norio *et al.*, 2010). Questionnaires were sent to cases two months after collection of culture-positive samples. Responses were received from 235 cases (58% response rate) and 201 cases were included in the study. Musculoskeletal symptoms were reported by 39% of respondents, with ReA diagnosed in 4% of cases (n = 8).

A seroprevalence study was conducted to determine evidence for preceding *Campylobacter* infections in ReA cases (Zautner *et al.*, 2014). A control group of healthy blood donors (n = 80) exhibited 16-26% *Campylobacter* seroprevalence, depending on the antibody used. ReA cases (n = 50) showed 70-78% seropositivity for *Campylobacter* antibodies. When adjusted for the seroprevalence in healthy controls, this suggests 44-62% of ReA cases may be associated with a preceding *Campylobacter* infection. There was also marked seropositivity for *Yersinia enterocolitica* amongst ReA cases and lower levels of seroprevalence for antibodies to *Helicobacter pylori*, *Mycoplasma pneumonia* and *Borrelia afzelii.*

Post-infectious sequelae to yersiniosis were assessed in participants of a large population-based case–control study on laboratory-confirmed *Yersinia enterocolitica* infections conducted in Germany in 2009–2010 (Rosner *et al.*, 2013). Cases were assessed through follow-up for four weeks. At follow-up 351 cases and 819 controls were interviewed. Symptoms consistent with ReA were reported in 12% of yersiniosis cases (n = 41) and 5% of controls (n = 39), giving a statistically significant risk ratio of 2.6. The incidence of symptoms of probable ReA increased with age.

A US Department of Defence medical database was used to examine the occurrence of ReA following a *Salmonella*, *Campylobacter*, *Shigella* or *Yersinia* infection in a retrospective cohort study (Porter *et al.*, 2013). Each case with gastroenteritis due to one of the four pathogens (n = 1753) was matched with four controls. Medical histories were analysed for six months post-infection for occurrence of ReA. Six of the cases (0.3%) were diagnosed with Reiter's disease (the main International Statistic Classification of Disease and Related Health Problems (ICD) descriptor equated to ReA) within six months of infection (median 22 days). One subject in the reference cohort (0.01%) was diagnosed with Reiter's disease 213 days after commencement of surveillance. Incidence rates of ReA in the infected population ranged from 0 per 100,000 person years following a *Yersinia* infection to 4.4 per 100,000 person years following a *Shigella* infection.

A prospective cohort study was carried out following an outbreak of *Salmonella* Hadar infection in Castellon province, Spain in 2005 (Arnedo-Pena *et al.*, 2010). Follow-up telephone interviews were conducted with 155 people with clinical salmonellosis and 93 non-infected family controls. Definitive or probable ReA was identified in 16 cases (10.3%), but not in any controls. Use of antibiotics to treat the *Salmonella* infection appeared to be protective for the development of ReA.

Between November 2003 and May 2004, questionnaires were sent to 999 consecutive Finnish cases with a *Salmonella*-positive stool sample (Tuompo *et al.*, 2013). Questionnaires were

returned by 496 cases (49.6%). Self-reported symptoms were followed up with clinical examination. ReA occurred in 4.4% (22/496) of cases, while 13.7% (68/496) had other reactive musculoskeletal symptoms. Development of musculoskeletal symptoms was associated with *Salmonella* infections with a longer duration of diarrhoea and higher occurrence of abdominal pain and fever. In contrast to the study of Arnedo-Pena *et al.* (2010), cases with musculoskeletal sequelae were more likely to have used antibiotics than those without musculoskeletal complications.

4.5.2 Inflammatory bowel disease (IBD)

A study in Chile recruited a cohort of Crohn's disease (CD) patients (*n* = 94) and healthy controls (*n* = 88) (Alvarez-Lobos *et al.*, 2013). The study found no difference in the frequency of previous exposure to *Salmonella* between CD patients and controls.

A seroprevalence study was conducted to determine evidence for preceding *Campylobacter* infections in IBD cases (Zautner *et al.*, 2014). A control group of healthy blood donors (*n* = 80) exhibited 16-26% *Campylobacter* seroprevalence, depending on the antibody used. IBD cases (*n* = 39) showed 49-56% seropositivity for *Campylobacter* antibodies. When adjusted for the seroprevalence in healthy controls, this suggests 23-40% of IBD cases may be associated with a preceding *Campylobacter* infection. The paper presented a discussion concerning whether bacterial infections lead to IBD or whether IBD predisposes an individual to bacterial infections.

The Danish population was followed for the period 1992-2008 (94.3 million person years), using national registers for the results of stool tests and patients with IBD (Jess *et al.*, 2011). There was an increased risk of Crohn's disease (CD) and ulcerative colitis (UC) in the year following a stool test positive for *Salmonella* or *Campylobacter*, with incidence rate ratios (IRRs) in the range 5.4 to 9.8. The risk remained elevated in the period 1-10 years after the positive stool test (IRRs 1.6-2.2), but was generally not significantly elevated after 10 years. However, the risk of a first hospital contact for CD or UC was even higher following a negative stool test. The authors speculate that this may suggest that any enteric infection may trigger IBD, but concluded that it is more likely that the observations represent a detection bias – that further investigations following a negative stool sample increase the likelihood of IBD being diagnosed.

4.5.3 Post infectious irritable bowel syndrome (PI-IBS)

PI-IBS is not currently included in the model used to determine the burden of foodborne disease in New Zealand. However, there is some evidence that this condition may be triggered by preceding infections with *Campylobacter*, *Salmonella* or norovirus (Haagsma *et al.*, 2010).

Patients with campylobacteriosis (*n* = 105) were assessed for single nucleotide polymorphisms (SNPs) in inflammatory cytokine genes (Nielsen *et al.*, 2012). The population distribution of the gene variants was also assessed in healthy controls (*n* = 192). Patients were then followed up six months later. PI-IBS had developed in 20 patients, but was not found to be associated with particular SNPs.

Between 2000 and 2009, 576 cases with confirmed *Salmonella* or *Campylobacter* infections were followed up by application of a two-tiered questionnaire (Schwille-Kiuntke *et al.*, 2011). Persistent symptoms, consistent with PI-IBS were reported in 9.7% of cases. Cases with moderate to severe PI-IBS were more likely to be female, have been infected with *Salmonella* rather than *Campylobacter*, have had more severe symptoms during the initial infection, and to have had gastrointestinal symptoms prior to the bacterial infection.

4.5.4 Guillain-Barré syndrome (GBS)

A systematic review of the association between *Campylobacter* infection and development of GBS was carried out (Poropatich *et al.*, 2010). The study concluded that 31% of 2502 GBS cases included in the papers reviewed were attributable to *Campylobacter* infection. The model used in the current study attributes 29% of GBS cases to preceding campylobacteriosis. Two cohort studies were reviewed that provided estimates of the incidence of GBS following campylobacteriosis. The estimates were 30.4 and 117 cases of GBS per 100,000 cases of campylobacteriosis. The current study estimated an intermediate value of 56 cases of GBS per 100,000 cases of campylobacteriosis.

A New Zealand study demonstrated a significant direct correlation between annual hospitalisation rates for GBS and annual notification rates for campylobacteriosis, over the period 1988-2010 (Baker *et al.*, 2012). During a post-intervention period, when the incidence of campylobacteriosis decreased for approximately 50%, the incidence of hospitalised GBS decreased by 13%, suggesting that approximately 25% of GBS cases were caused by preceding campylobacteriosis. Baker *et al.* also found that of 8448 cases hospitalised for campylobacteriosis, 35 were also hospitalised for GBS. A person hospitalised for campylobacteriosis has a 320-fold greater risk of developing GBS than the general population.

It has been suggested that *Campylobacter* causes GBS due to molecular similarities between *Campylobacter* lipo-oligosaccharides (LOS) and gangliosides in nervous tissue, leading to an autoimmune response (Islam *et al.*, 2012). A case-control study with GBS cases (n = 97) and neurological or family controls (n = 120) found antibodies to four specific *Campylobacter* LOS in 14-58% of GBS cases, but less than 3% of controls. GBS cases were also found to more frequently have serum antibodies to specific gangliosides (56%) than neurological (1%) or family (6%) controls. Monoclonal antibodies raised to human gangliosides were found to strongly cross-react with two of the LOS variants.

A prospective cohort study of GBS cases from the greater Paris region of France was conducted between 1996 and 2007 (Sivadon-Tardy *et al.*, 2014). Cases (n = 557) for whom a pre-treatment serum sample was available were included in the study. Antibodies to *Campylobacter jejuni* were detected in 153 (27.5%) cases. *Campylobacter*-positive GBS cases had a mean age of 51.5 years. Compared to *Campylobacter*-negative GBS cases, *Campylobacter*-positive GBS cases were more likely to be males (66·2% vs. 54·2%, P=0·012), to have had prodromal diarrhoea (46·4% vs. 12·9%, P<0·0001), to have a pure motor GBS form (57·3% vs. 31·0%, P<0·0001) or Miller-Fisher syndrome (4·0% vs. 0·5%, P=0·006), to have anti-ganglioside (GM1) antibodies (32·7% vs. 3·9%, P<0·0001) and to have severe long-term sequelae (14·7% vs. 4·8%, P=0·0015). *Campylobacter*-positive GBS cases increased significantly through the time course of the study and this correlated with

increases in *Campylobacter jejuni* isolations from gastroenteritis cases during the same period.

A seroprevalence study was conducted to determine evidence for preceding *Campylobacter* infections in GBS cases (Zautner *et al.*, 2014). A control group of healthy blood donors (*n* = 80) exhibited 16-26% *Campylobacter* seroprevalence, depending on the antibody used. GBS cases (*n* = 91) showed 60-65% seropositivity for *Campylobacter* antibodies. When adjusted for the seroprevalence in healthy controls, this suggests 34-49% of GBS cases may be associated with a preceding *Campylobacter* infection.

Evidence of preceding *Campylobacter jejuni* infection (IgG and IgM antibodies) was found in 30% (15/50) of a cohort of GBS cases, compared to 8% (3/40) of a cohort of matched controls (Sharma *et al.*, 2011). Of the GBS cases seropositive for *C. jejuni* exposure, 53% (8/15) reported gastrointestinal symptoms between 4 and 30 days prior to onset of GBS. For GBS cases seronegative for *C. jejuni* exposure, 26% (9/35) reported prior gastrointestinal symptoms.

Serum antibodies were used as an indicator of recent infection with *Campylobacter jejuni*, *Mycoplasma pneumonia*, cytomegalovirus (CMV) and Epstein-Barr virus (EBV) in a cohort of GBS cases (*n* = 306) (Caudie *et al.*, 2011). Evidence of a preceding infection was found in 43.8% of GBS cases (134/306). The most common agent was *C. jejuni*, with evidence of infection in 24.8% of GBS cases (76/306), followed by CMV (12.4%), *M. pneumonia* (3.3%) and EBV (1.3%). Anti-ganglioside antibodies were detected in 31.7% of all GBS cases, but were detected in 73.7% (56/76) of GBS cases with evidence of a preceding *C. jejuni* infection.

4.5.5 Other sequelae

Erythema nodosum (EN, inflammation of fat cells under the skin) and conjunctivitis (CON, inflammation of the conjunctiva) have been associated with preceding yersiniosis (Bottone, 1997).

Post-infectious sequelae to yersiniosis were assessed in participants of a large population-based case–control study on laboratory-confirmed *Yersinia enterocolitica* infections conducted in Germany in 2009–2010 (Rosner *et al.*, 2013). At four weeks follow-up 351 cases and 819 controls were interviewed. Symptoms consistent with EN were reported in 3% of yersiniosis cases (*n* = 11) and 0.1% of controls (*n* = 1), giving a statistically significant risk ratio of 25. Occurrence of CON was not significantly different between the case and control groups.

4.6 Burden of Foodborne Disease Due to Chemicals

While most studies on the burden of foodborne disease consider only microbial diseases, publications on application of the DALY metric to chemical issues are starting to appear. It should be noted that the Global Burden of Foodborne Disease project includes consideration of a limited range of chemical food safety issues (World Health Organization, 2008a)

4.6.1 Chatham-Stephens *et al.* (2013)

This study derived DALY estimates for a number of toxic waste sites in India, Indonesia and the Philippines (Chatham-Stephens *et al.*, 2013). For each site the key contaminant was identified and concentrations of that contaminant were determined, usually in one medium (water, soil or air). Toxicological effects were considered and the main carcinogenic (if relevant) and non-carcinogenic effects were identified. Dose-response information was combined with concentration data and estimates of the number of people exposed to the contaminated medium from the site to derive estimates of the incidence of disease. For carcinogenic endpoints a standard time course of five years was modelled, after which time the cases were considered to have either died or gone into remission. Non-cancer diseases were assumed to continue life-long, but without mortality. Disability weights were taken from the 2004 update of the Global Burden of Disease study (World Health Organization, 2008b).

5 CONCLUSIONS

Application of the DALY approach to potentially foodborne infectious intestinal disease in New Zealand allows a ranking of food safety issues. Of the six potentially foodborne microbial diseases examined in the current exercise the highest ranked issue, according to the DALY approach is norovirus infection (depending on the method used to calculate the total number of cases), followed by campylobacteriosis, listeriosis, STEC infection, salmonellosis, and yersiniosis. However, it should be noted that, for most diseases, the 95th percentile intervals for the DALY estimates are quite wide and overlap the intervals for other diseases. Where intervals overlap, it cannot be stated that DALY estimates are significantly different and the ranking order derived should be viewed as indicative. The high ranking of norovirus infection is due to the large number of cases estimated. *Campylobacter* ranks highly due to its high incidence, but also because of the range and seriousness of its sequelae.

Changes in DALY estimates from 2011 to 2013 mainly reflect changes in notification of the diseases, while changes in foodborne DALY estimates reflect both changes in notifications and changes in the foodborne proportion, as estimated by expert elicitation. Changes in the age distribution of STEC infection cases has also had an impact on the predicted incidence of sequelae (HUS and ESRD) and associated DALYs. A substantial decrease in the estimated foodborne proportion for STEC infection has also impacted on the DALY estimates.

Estimates associated with different organisms vary widely in their degree of associated uncertainty. For example, the model used to calculate DALYs associated with STEC infection generates a 95th percentile interval for the total number of gastroenteritis cases that spans three orders of magnitude, while the total range of mean DALY values for all diseases considered only cover two orders of magnitude.

Decisions made in the construction of the model can have major impacts on the final DALY value. For STEC infection, 90% of the DALY estimate is due to the long term sequelae that can result from infection (HUS and ESRD). While the evidence used to extrapolate from reported STEC infection cases to unreported cases and to sequelae is the best currently available, in most cases it is not New Zealand specific and it is possible that patterns of illness in New Zealand may be different to those observed overseas. For example, the model estimates a mean incidence of 82 cases per year of HUS due to STEC infection, while in the 2013 year a total of only 50 cases of HUS were reported to be hospitalised in New Zealand (Horn *et al.*, 2014).

In addition, no adjustment of DALY estimates for comorbidity was made. This may be an important factor in estimating YLL where deaths occur in elderly people (e.g. for norovirus and acquired listeriosis), as the fatality risk is increased by other conditions.

Despite these issues, the DALY approach provides a useful mechanism for assimilating a huge amount of information on infectious intestinal diseases, that would otherwise not be comparable, to produce a single ranking metric suitable as an input to risk prioritisation.

International developments in estimation of the burden of foodborne disease do not suggest that changes to the methodology currently used in New Zealand are required. However, of the sequelae included in the current DALY model, there are some questions as to whether

there is a causative relationship between bacterial gastrointestinal infections and IBD; and if so, which microbial species represent predisposing factors.

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APPENDIX 1 COMPARISON OF ESTIMATES OF THE INCIDENCE OF SELECTED FOODBORNE DISEASES AND DISEASE STATES BETWEEN 2011 AND 2013

Disease state	Incidence (mean cases per year, 95th percentile interval)		Reason for difference
	2011	2013	
Campylobacteriosis			
GE, total	63,800 (43,000-90,000)	65,200 (44,000-92,800)	Slightly increased notifications
GE, no GP	55,000 (34,000-81,000)	56,200 (35,000-82,900)	Slightly increased notifications
GE, GP only	8,800 (6,400-11,500)	8,980 (6,550-11,700)	Slightly increased notifications
GE, Hospitalisation	574	709	Increased hospitalisations
GE, Death	0.4 (0-2)	0.4 (0-2)	
GBS, total	36 (24-49)	32 (23-40)	Decrease in GBS cases
GBS, mild	7.1 (3-12)	6.2 (3-11)	Decrease in GBS cases
GBS, severe	29 (21-37)	25 (18-33)	Decrease in GBS cases
GBS, death	1.3 (0-3)	1.1 (0-3)	Decrease in GBS cases
ReA, total	660 (440-930)	676 (450-950)	Indexed to 'GE, GP only' figure
ReA, no GP	520 (340-750)	532 (340-760)	Indexed to 'GE, GP only' figure
ReA, GP	112 (37-208)	115 (40-210)	Indexed to 'GE, GP only' figure
ReA, Hospitalisation	28 (4-69)	29 (4-71)	Indexed to 'GE, GP only' figure
IBD, total	23 (16-32)	24 (17-33)	Slightly increased notifications
Salmonellosis			
GE, total	6,300 (1,600-15,500)	6,820 (1,710-16,700)	Increased notifications
GE, no GP	4,700 (0-13,900)	5,060 (0-15,100)	Increased notifications
GE, GP only	1,600 (700-3,000)	1,760 (790-3,280)	Increased notifications
GE, Hospitalisation	135	146	Slightly increased hospitalisations
GE, Death	0.6 (0-2)	0.5 (0-2)	Reduced case mortality rate
ReA, total	134 (47-277)	145 (50-300)	Indexed to 'GE, GP only' figure
ReA, no GP	105 (36-218)	114 (40-240)	Indexed to 'GE, GP only' figure

Disease state	Incidence (mean cases per year, 95th percentile interval)		Reason for difference
	2011	**2013**	
ReA, GP	23 (6-54)	25 (4-60)	Indexed to 'GE, GP only' figure
ReA, Hospitalisation	5 (0-16)	6 (0-19)	Indexed to 'GE, GP only' figure
IBD, total	3 (1-7)	3.6 (1-7)	Indexed to notifications
Listeriosis (Perinatal)			
Sepsis	1.4 (0-3)	1.5 (0-3)	
Meningitis	0.5 (0-2)	0.6 (0-2)	
Pneumonia	1.2 (0-3)	1.3 (0-3)	
Death - perinatal - neonatal	 1.8 (0-4) 0.1 (0-1)	 1.7 (0-4) 0.6 (0-2)	
Neurological sequelae	0.3 (0-1)	0.3 (0-1)	
Listeriosis (acquired)			
Sepsis	7.0 (3-12)	4.2 (1-8)	Decreased notifications
Meningitis	9.9 (5-15)	6.4 (3-10)	Decreased notifications
Gastroenteritis	5.2 (2-9)	3.0 (1-6)	Decreased notifications
Pneumonia	5.2 (2-9)	3.0 (1-6)	Decreased notifications
Death	2.6 (0-6)	1.9 (0-4)	Decreased notifications
Neurological sequelae	1.4 (0-4)	0.9 (0-3)	Decreased notifications
STEC infection			
GE, total	2,830 (120-10,500)	3,800 (160-14,100)	Increased notifications
GE, bloody	1,260 (52-4,680)	1,700 (70-6,200)	Increased notifications
GE, non-bloody	1,570 (67-5,880)	2,110 (90-7,800)	Increased notifications
GE, hospitalisation	18	27	Increased hospitalisations
GE, death	0.1 (0-1)	0.1 (0-1)	Reduced case mortality rate
HUS, clinical	77 (3-290)	82 (3-300)	Indexed to 'GE, total' figure and age distribution of STEC notifications

Disease state	Incidence (mean cases per year, 95th percentile interval)		Reason for difference
	2011	**2013**	
HUS, death	3.1 (0-13)	3.7 (0-15)	Indexed to 'GE, total' figure and age distribution of STEC notifications
ESRD	8.8 (0-35)	9.1 (0-37)	Indexed to 'GE, total' figure and age distribution of STEC notifications
Yersiniosis			
GE, total	9,500 (7,000-12,300)	8,940 (6,520-11,600)	Slightly decreased notifications
GE, no GP	7,900 (5,400-10,700)	7,460 (5,050-10,100)	Slightly decreased notifications
GE, GP only	1,600 (1,500-1,650)	1,480 (1,370-1,600)	Slightly decreased notifications
GE, Hospitalisation	39	46	Slightly increased hospitalisation
GE, Death	0.1 (0-1.0)	0.1 (0-1)	
ReA, total	95 (57-140)	90 (54-132)	Indexed to 'GE, GP only' figure
ReA, no GP	75 (44-113)	71 (41-107)	Indexed to 'GE, GP only' figure
ReA, GP	16 (4-32)	15 (3-31)	Indexed to 'GE, GP only' figure
ReA, Hospitalisation	4.1 (0-11)	3.8 (0-10)	Indexed to 'GE, GP only' figure
Norovirus infection (based on rate ratios)			
GE, total	20,800 (17,700-24,200)	21,900 (18,000-24,500)	
GE, no GP	19,900 (16,800-23,300)	20,100 (17,000-23,600)	
GE, GP only	930 (670-1,240)	940 (680-1,260)	
GE, Hospitalisation	160	104	Decreased hospitalisations
GE, Death	4.4 (1-8)	5.0 (2-9)	
Norovirus infection (based on rates)			
GE, total	208,000 (178,000-242,000)	211,000 (180,000-245,000)	
GE, no GP	199,000 (168,000-232,000)	202,000 (170,000-236,000)	

Disease state	Incidence (mean cases per year, 95th percentile interval)		Reason for difference
	2011	**2013**	
GE, GP only	9,400 (6,600-12,500)	9,500 (6,700-12,700)	
GE, Hospitalisation	160	104	Decreased hospitalisations
GE, Death	4.4 (1-8)	5.0 (2-9)	Increased case mortality rate

GE: gastroenteritis, GBS: Guillain-Barré Syndrome, ReA: reactive arthritis, IBD: inflammatory bowel disease, HUS: haemolytic uraemic syndrome, ESRD: End Stage Renal Disease, STEC: shiga-toxin producing *E. coli*, GP: general practitioner