Ministry for Primary Industries
Manatū Ahu Matua

Risk Ranking: Updated Estimates of the Burden of Foodborne Disease for New Zealand in 2011

MPI Technical Paper No: 2012/12

Prepared for Ministry for Primary Industries
by Peter Cressey

ISBN No: 978-0-478-40005-2
ISSN No: 2253-3923

June 2012

New Zealand Government

Growing and Protecting New Zealand

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Client Report FW12030

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Prepared for the Ministry for Primary Industries
under project MRP/11/07, Risk Ranking: DALYs - Updating,
as part of overall contract for scientific services

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August 2014

AMENDMENT RECORD

<table>
<tr><th>Version Date</th><th colspan="2">Reason for update</th></tr>
<tr><td>June 2012</td><td colspan="2">First Edition</td></tr>
<tr><td rowspan="4">August 2014</td><td colspan="2">Correction to the new (2011) estimate of years lived with disability (YLD) for gastroenteritis (GE) due to campylobacteriosis. The originally report figure (793) has been amended to 705. Consequent changes to the total YLDs, GE DALYs, total DALYS and foodborne DALYs for campylobacteriosis have also been made.</td></tr>
<tr><td>Section</td><td>Change to document</td></tr>
<tr><td>3.2</td><td>Table 6, change to figures for campylobacteriosis</td></tr>
<tr><td>3.3</td><td>Table 7, change to figures for campylobacteriosis</td></tr>
<tr><td>3.4</td><td>Table 8, change to 2011, no RC figures for campylobacteriosis</td></tr>
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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 for the following illnesses (in order of decreasing burden) were modelled:

- Campylobacteriosis
- Norovirus infection
- Listeriosis (invasive, perinatal)
- Salmonellosis
- Yersiniosis
- STEC infection
- Listeriosis (invasive, non-perinatal)

A significant proportion of these illnesses are caused by foodborne transmission of the pathogens (40-90+ %, depending on the pathogen). Estimates were based mainly on data from the 2005 year.

It was considered timely to update these DALY estimates to take into account:

- New Zealand surveillance data for the 2011 calendar year (ESR, 2012; Lim *et al.*, 2012).
- Dutch disability weights specifically determined for foodborne disease, either including or excluding the 'relevance criterion' (Haagsma *et al.*, 2008a). Application of the relevance criterion results in some mildly adverse health states being assigned a zero disability weight.
- Where applicable, multipliers derived from the British IID2 study (Tam *et al.*, 2011).
- Alternative approaches to attribution of campylobacteriosis cases.

Actual changes in disease notifications and application of multipliers from the IID2 study had the greatest impact on DALY estimates, with the mean DALY estimates for norovirus infection and STEC infection increasing markedly. However, the DALY estimates for STEC infection contained a high level of uncertainty. The updated ranking in terms of foodborne DALYs is:

- Norovirus infection
- Campylobacteriosis
- STEC infection
- Listeriosis (invasive, perinatal and non-perinatal)
- Salmonellosis
- Yersiniosis

The application of the relevance criterion has the most marked effect on the estimated foodborne DALYs for norovirus infection. This is not surprising as the disease burden due to norovirus infection is mainly due to the large number of mild cases of gastroenteritis. With the application of the relevance criterion these cases are assigned a zero disability weight.

Application of the relevance criterion leaves campylobacteriosis as the highest ranked disease, followed by STEC infection and listeriosis.

Application of alternative attribution schemes for campylobacteriosis, based on source attribution, increases the 2005 estimates of foodborne DALYs, no matter which alternative scenario is considered. For the 2011 year, the base case (attribution based on expert opinion) produces an estimate of foodborne DALYs intermediate between defining foodborne as all poultry source cases and defining foodborne as all poultry source cases and 25% of ruminant source cases.

While it is not possible to say which of these attribution approaches is most accurate, it appears likely that the estimate of the proportion of campylobacteriosis that is foodborne derived from expert elicitation may have underestimated this proportion for 2005. However, no matter which attribution scheme is adopted, the relative ranking of campylobacteriosis on the basis of foodborne DALYs remains unchanged (i.e. always the top ranked in 2005 and the top ranked in 2011, if a relevance criterion is applied).

1 INTRODUCTION

This report contributes to an on-going project to rank the risks associated with pathogens in New Zealand food, with the following goal:

- To update the DALY risk ranking metric, that has been applied to microbiological foodborne hazards, with 2011 data.

During 2006-2007 estimates for the burden of foodborne disease in New Zealand were derived. 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 studies used disability-adjusted life years as the metric for estimation of the burden of foodborne disease.

1.1 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:

$$\text{DALY} = \text{YLL} + \text{YLD}$$

YLL is the number of years of life lost due to mortality and YLD is the number of years lived with a disability, weighted with a factor between 0 and 1 for the severity of the disability (d).

YLL is calculated by accumulation over all health outcomes (l), the product of the number of fatal cases (n) due to the health outcomes (l) multiplied by the expected individual life span (e) at the age of death.

$$YLL = \sum_l n_l \times e_l$$

YLD is calculated by accumulation over all health outcomes (l), the product of the number of cases (n), the duration of the illness (t) and the disability weight (w) of a specific disease. It should be noted that the calculation for YLL above implicitly includes a disability weight factor. The disability weight factors are in the range zero to one, with the disability weight for death being equal to one.

$$YLD = \sum_l n_l \times t_l \times w_l$$

Information on the incidence of illness and death is derived from clinical, epidemiological and surveillance studies, whereas information on disability weights is typically derived from elicitation of special panels, preferably from the general population.

1.2 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) Ltd., 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.

1.3 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.*, 2011), 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 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, for disease due to ten enteric pathogens (*Clostridium perfringens, Campylobacter, Salmonella, E. coli* O157, *Cryptosporidium, Giardia,* adenovirus, astrovirus, norovirus and rotavirus) (Tam *et al.*, 2011).

From this study, multipliers were available for three of the organisms considered in the New Zealand burden of foodborne illness study (*Campylobacter*, norovirus, *Salmonella*). Ratios were also derived for *Escherichia coli* O157 VTEC. However, there were insufficient data to derive a ratio for GP presenting cases to national surveillance cases for this organism.

1.4 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. This may be presented along with symptoms description in the form of A4 vignettes

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 (Tobias, 2001) used disability weights principally from the Netherlands and Australia. Disability weights previously used to determine the burden of foodborne disease for New Zealand have been 'borrowed', with the Netherlands being the most comprehensive source (Kemmeren *et al.*, 2006).

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 (Kemmeren *et al.*, 2006; Cressey and Lake, 2007). 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 have been used to re-evaluate DALY estimates for foodborne disease in New Zealand (Cressey and Lake, 2009).

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 (Krabbe *et al.*, 1997; Haagsma *et al.*, 2008a); 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.

1.5 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 from an expert elicitation process (Cressey and Lake, 2005).

Considerable work has been carried out in New Zealand on source attribution of campylobacteriosis (French, 2008; 2009; French and Marshall, 2010; French, 2012). These

studies have been conducted in the Manawatu region. Source attribution is distinctly different to transmission pathway attribution, as it is primarily informative about the origins of the organism, rather than the mechanism of human exposure. However, it is possible to define assumptions or scenarios to equate sources to pathways.

1.6 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). This update will include:

- New Zealand surveillance data for the 2011 calendar year (ESR, 2012; Lim *et al.*, 2012).
- Dutch disability weights specifically determined for foodborne disease, either including or excluding the 'relevance criterion' (Haagsma *et al.*, 2008a). Application of the relevance criterion results in some mildly adverse health states being assigned a zero disability weight.
- Where applicable, multipliers derived from the British IID2 study (Tam *et al.*, 2011).
- Alternative approaches to attribution of campylobacteriosis cases.

2 DALY ESTIMATES: GENERAL CONSIDERATIONS

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

- Campylobacteriosis
- Salmonellosis
- Listeriosis (invasive, perinatal and non-perinatal)
- Infection with shiga-toxin producing *Escherichia coli* (STEC)
- Yersiniosis
- Infection with norovirus

According to an expert consultation conducted for a risk ranking process in 2005, a significant proportion of these illnesses are caused by foodborne transmission of the pathogens (40-90+ %) (Cressey and Lake, 2005).

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

It should be noted that no new disability weights have been derived for the health states resulting from listeriosis. Similarly, listeriosis was not a condition included in IID2. Consequently, updated DALY estimates for listeriosis will only reflect changes in notifications, hospitalisations and deaths for this condition.

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

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 2011 calendar year (ESR, 2012).

DALY estimates can be strongly affected by rare events amongst the New Zealand population e.g. disease specific mortality. Whether or not deaths had occurred due to a particular illness in a specific year could change the estimates considerably. The approach taken for such components of the burden of illness was to generate distributions that described the incidence of such outcomes over a period of several years, usually the years 2002-2011. This also enabled the production of distributions such as age ranges for cases involved in such rare events. Data were taken from EpiSurv

2.2 Outcomes

The adverse health outcomes resulting from these illnesses define the components of the DALY estimate. It is essential to define the specific outcomes for each illness.

The principal outcome for these illnesses (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 rehydration solutions, pain killers, or anti-diarrhoea medicines. 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.
- Visit a GP and recover
- Hospitalised and recover
- 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 e.g. for infection with STEC, AGI with or without bloody diarrhoea may occur.

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 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 (IBS) has been associated with gastroenteritis caused by a range or bacterial and viral pathogens (Thabane *et al.*, 2007; Haagsma *et al.*, 2010). 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. However, as the current study is an update of previous burden of foodborne disease estimates for New Zealand (Cressey and Lake, 2007) that did not include PI-IBS as a sequel to gastrointestinal disease, PI-IBS has not been included in the calculations for the current study. PI-IBS was not included as a sequel in the earlier New Zealand study, because the link to acute gastrointestinal disease was not well established at that time.

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).

2.2.1 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)

Campylobacteriosis Sequelae:

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

Inflammatory bowel disease (IBD) is a collective term used to describe a group of chronic intestinal 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.

2.2.2 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)

Salmonellosis Sequelae:

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

2.2.3 Listeriosis

A review of the literature for the Netherlands study indicated that the adverse outcomes for the foetus of *Listeria* infection in the mother were:

- Abortion, still birth
- Liveborn infected: severe systemic infection, sepsis, pneumonia, CNS infection (meningitis)

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

2.2.4 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 due to dialysis, transplantation and graft rejection

2.2.5 Yersiniosis

This illness was not considered in the Dutch study. We consider 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)

Yersiniosis Sequelae:

Although there are a range of complications resulting from yersiniosis, 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 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

2.2.6 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 death:

- **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
- **Hospitalisations**
- **Long term sequelae**
- **Mortality**

The DALY method requires estimation of the number of cases at each of the bolded levels. However, the primary dataset we have used concerns notifications. Consequently there is a need to apply scaling factors (multipliers) to the number of notifications to estimate the number of laboratory-confirmed cases, and then to apply another scaling factor to estimate

the number of cases attending a GP and finally to apply another scaling factor to estimate the total number of cases.

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

IID2 calculated rate ratios (multipliers) by assuming that the rates came from a lognormal distribution with the observed mean and standard deviation (Tam *et al.*, 2011). The rate ratio was then calculated by simulation modelling of 'draws' from these lognormal distributions. The median, 2.5th and 95th 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 population, 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 (Wheeler *et al.*, 1999; Tam *et al.*, 2011). This is most marked for the total incidence of norovirus infection (community incidence), where the community rate has increased from 12.5 case 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 (2011 midpoint).

2.4 Life expectancy

Statistics New Zealand provides tables that show life expectancy for males and females at ages up to 100 years, for the reference years 2005-2007. [1] These were used for calculations in these DALY estimates.

2.5 Disability Weights

The determination of novel disability weights for the Netherlands used VAS and 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 (Ustun *et al.*, 1999; Essink-Bot *et al.*, 2002), 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 for each of two scenarios:

- The relevance criterion was not applied and mean TTO values were used for these mild health states; and
- The relevance criterion was applied and zero TTO values were used for these mild health states.

[1] http://www.stats.govt.nz/browse_for_stats/health/life_expectancy/period-life-tables.aspx

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

State	VAS mean	TTO transformed[1]	TTO median	TTO mean	Relevance Criterion (%TTO=0)
Gastroenteritis, mild, 1 day	0.036	0.0004	0	0.002	88[2]
Gastroenteritis, mild, 5 days	0.102	0.004	0	0.01	60[2]
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[2]
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] 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)

2.6 Attribution: Percentage Foodborne

The proportion of the DALY burden of illness estimates attributed to foodborne transmission of the pathogens has been calculated using attribution estimates provided by an expert consultation workshop conducted in May 2005 (Cressey and Lake, 2005). The mean values for the expert estimates of minimum, most likely, and maximum were treated as a Pert distribution for modelling purposes. The relevant data for the illnesses being considered are given in Table 3.

Table 3: Proportion of disease due to foodborne transmission – summary of expert opinion, May 2005

Disease	Proportion foodborne[1]		
	Minimum (%)	Most Likely (%)	Maximum (%)
Campylobacteriosis	37.1	57.5	69.6
Salmonellosis	45.4	60.7	68.9
Listeriosis	78.4	84.9	92.1
STEC infection	27.0	39.6	51.4
Yersiniosis	41.5	56.2	70.8
Norovirus infection	27.9	39.6	48.9

[1] from Cressey and Lake (2005)

The panel from whom these data were elicited included 14 experts in food microbiology, clinical microbiology, epidemiology or public health. Opinions were collected by application of a two pass modified Delphi, with a facilitated discussion between the first and second application of the elicitation questionnaire. Results in Table 3 are from the second pass.

2.6.1 Alternative attribution models for campylobacteriosis

The Manawatu source attribution studies included the following sources: chicken , duck, turkey, spent hen, cattle, sheep, dog/cat, wild water bird, other wild bird, and water.

Source attribution percentages were reported as mean, 2.5th and 97.5th percentiles (French, 2012). The mean and percentiles for each source are summarised in Table 4.

Table 4: Attribution of campylobacteriosis cases in the Manawatu to sources, 2005/2006 and 2010/2011

Source	Percentage of human cases attributable to source[1]					
	2005/2006			2010/2011		
	Mean	2.5%	97.5%	Mean	2.5%	97.5%
Chicken[2]	75.0	60.0	86.9	46.8	30.7	59.7
Duck	0.6	0.0	2.1	0.9	0.0	3.5
Turkey	1.0	0.0	3.7	1.8	0.0	6.8
Spent hen	1.1	0.0	4.2	2.6	0.1	9.0
Cattle	14.0	4.0	24.8	17.0	2.0	36.0
Sheep	4.1	0.1	12.2	21.5	4.2	39.0
Dog/cat	1.2	0.0	4.5	3.2	0.1	13.2
Wild water bird	0.6	0.0	2.3	1.3	0.0	4.7
Other wild bird	0.7	0.0	2.7	2.4	0.1	7.5
Water	1.7	0.1	5.3	2.4	0.1	7.6

[1] Reproduced from (French, 2012)

[2] In the source document the proportion of cases of campylobacteriosis due to chicken was separated into the three major suppliers in the Manawatu region. For the current exercise, these proportions have been combined into a single chicken proportion by simulation modeling

These percentiles were used to define lognormal distributions for use in simulation modelling. In some instance, the percentiles did not allow fitting to a lognormal distribution

and a beta (pert) distribution was used instead. This is consistent with the right-skewed nature of the uncertainty intervals. The lognormal distribution was chosen as the original attribution analysis employed lognormal prior distributions.

For the current study, three scenarios were examined; that foodborne is equivalent to the proportion of cases originating from poultry (chicken, duck, turkey, spent hen), poultry and 25% of ruminant (cattle, sheep), and poultry and 75% of ruminants. These scenarios were selected based on the view that poultry-associated cases are likely to be almost all foodborne, while ruminant-associated cases will include a variety of transmission pathways, including foodborne and direct animal contact.

Estimates of foodborne DALYs will be directly dependent on the figure used for the foodborne proportion. Table 5 summarises the four scenarios for calculating foodborne proportions for campylobacteriosis; the base case with the proportion foodborne based on expert elicitation and three scenarios with the proportion foodborne based on source attribution figures.

Table 5: Foodborne proportion for campylobacteriosis as influenced by different attribution approaches

Scenario	Mean foodborne proportion (%) of campylobacteriosis (90% CI)[1]	
	2005/2006	2010/2011
Base (expert elicitation)	56.1 (45.6-65.5)	56.1 (45.6-65.5)
Foodborne = Poultry	76.3 (65.3-88.7)	49.9 (35.8-66.8)
Foodborne = Poultry + 25% Ruminant	80.0 (68.8-92.6)	57.4 (42.6-75.4)
Foodborne = Poultry + 75% Ruminant	87.3 (74.7-100)	72.2 (52.7-96.6)

[1] Derived from simulation

Assuming that the source attribution studies carried out in the Manawatu are generalisable across New Zealand, the information in Table 5 suggests that the expert elicitation carried out in 2005 may have underestimated the foodborne proportion of campylobacteriosis for New Zealand. Alternatively, if the expert elicitation proportion is accepted, then a significant proportion of poultry and ruminant sourced cases are being exposed through a non-food transmission pathway.

Foodborne DALYs were calculated for each of these scenarios for two time periods 2005/2006 (prior to poultry industry interventions) and 2010/2011 (the most recent year of available data) (French, 2012).

3 RESULTS AND DISCUSSION

Since the last calculation of DALYs for selected foodborne diseases in New Zealand (Cressey and Lake, 2009), four 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 disease multipliers, due to adoption of IID2 multipliers.
- Treatment of disability weights, specifically, whether or not to apply the relevance criterion.
- Further information on the attribution of certain diseases (campylobacteriosis).

In order to examine the impact of these various factors on DALY estimates, the updated estimates will be compared to the old in two stages:

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

3.1 Incidence of Potentially Foodborne Diseases

The impact of the current estimation protocols on disease incidence is examined in Appendix 1.

For campylobacteriosis, the estimated number of cases has approximately halved from 2005 to 2011, due to a marked decrease in disease notifications. The change is even more marked for the estimated number of cases diagnosed by a GP. The multiplier derived from the IID2 study suggests that most cases diagnosed by a GP will be notified, whereas the 2005 calculations were based on a study that suggested only about 40% of cases diagnosed by a GP would be notified (Sarfati *et al.*, 1997). ReA cases are indexed to GP diagnosed gastroenteritis cases in the current model and estimates of ReA case numbers have reduced to about 20% of 2005 estimates. Campylobacteriosis-related GBS cases are calculated as a percentage of total GBS hospitalised cases and the number of cases has changed little between 2005 and 2011. Estimated IBD cases have decreased proportionally to the decrease in campylobacteriosis notifications.

Estimates of salmonellosis cases and related sequelae have been most affected by a decrease in the multipliers used. This resulted in estimated case numbers for 2011 in most categories being about one third of those in 2005.

Listeriosis (perinatal and acquired) case numbers were only marginally different between 2005 and 2011. The main differences were a lower perinatal case mortality rate and a higher acquired case mortality rate.

Estimates of STEC infection cases increased markedly from 2005 to 2011, due to actual increases in notifications and a large increase in the multipliers. HUS and ESRD cases are indexed to STEC case numbers and showed a similar marked increase.

As no novel multipliers were available for yersiniosis, the estimated case numbers for this disease have only changed proportionally to the difference in notifications between 2005 and 2011.

As discussed earlier, estimates of norovirus cases are influenced markedly by changes in the multipliers. There has also been an increase in the reported case mortality rate since 2005.

3.2 Burden of Potentially Foodborne Diseases (DALYs)

Table 6 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). These figures relate to the case where IID2 multipliers were applied for new estimates, and Dutch disability weight, without application of the relevance criterion, and expert elicitation attribution estimates were applied for old and new estimates. Surveillance data were from 2005 for old estimates and from 2011 for new estimates.

Changes in the estimates of foodborne DALYs are mainly due to changes in the estimated incidence of disease, as outlined in Appendix 1. For campylobacteriosis, YLD due to gastroenteritis has approximately halved, with a concomitant halving of the foodborne DALYs. This is consistent with observed changes in disease notifications. YLD and foodborne DALYs for salmonellosis have decreased by approximately a factor of three. This is mainly due to the multiplier used, rather than any major decreases in notification.

The disparity between the foodborne DALYs for norovirus infection calculated by the two alternative approaches highlights the problem of estimating disease incidence for non-notifiable diseases. The incidence estimates based on rate ratios appear implausibly low. This is perhaps not surprising, as the protocols for norovirus cases being notified is unlikely to be equivalent between New Zealand and the UK.

The adoption of incidence multiplier from the British IID2 study has had a significant impact on DALY estimates for STEC infection, with estimates increasing by approximately a factor of five. However, it should be noted the multiplier for this disease includes considerable uncertainty.

Table 6: Updated DALY estimates for selected foodborne diseases in New Zealand

Disease State	YLL		YLD		DALYs		Foodborne DALYs	
	Old[1]	New	Old[1]	New	Old[1]	New	Old[1]	New
Campylobacteriosis and sequelae								
GE	30	9	1483	705	1513	714		
GBS	18	21	70	80	88	101		
ReA			145	30	145	30		
IBD			247	112	247	112		
Total	**48**	**30**	**1945**	**927**	**1993**	**957**	**1118**	**540**
Listeriosis								
Total	**249**	**180**	**5.5**	**8.0**	**255**	**188**	**217**	**160**
Norovirus infection (Rate ratios)								
Total	**6**	**91**	**4260**	**219**	**4266**	**310**	**1682**	**122**
Norovirus infection (Population rates)								
Total	**6**	**91**	**523**	**2135**	**529**	**2226**	**207**	**873**
Salmonellosis and sequelae								
GE	46	15	197	77	243	92		
ReA			11	4	11	4		
IBD			22	17	22	17		
Total	**46**	**15**	**230**	**97**	**276**	**112**	**164**	**67**
STEC infection and sequelae								
GE	33	5	2	44	35	49		
HUS	26	195	0.5	4	27	199		
ESRD	14	95	20	162	34	257		
Total	**73**	**295**	**22.6**	**210**	**96**	**505**	**38**	**200**
Yersiniosis and sequelae								
GE	29	2	87	104	50	106		
ReA			4	4	4	4		
Total	**29**	**2**	**91**	**109**	**120**	**111**	**67**	**62**

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

[1] Except for listeriosis, these figures predominantly come from Cressey and Lake (2009) and are based mainly on 2005 New Zealand surveillance data, the most recent Dutch disability weights (Haagsma *et al.*, 2008a) excluding application of a relevance criterion and multipliers from a variety of sources including IID1 (Wheeler *et al.*, 1999). The figures for listeriosis come from the earlier study of Cressey and Lake (2007).

3.3 Ranking of Potentially Foodborne Diseases

DALY estimates are summarised and ranked in order of decreasing foodborne DALYs in Table 7.

Table 7: Mean YLD, YLL, DALYs and foodborne DALYs for potentially foodborne infectious intestinal diseases in New Zealand, 2011

Disease	YLD	YLL	DALYs	Foodborne DALYs (5^{th}-95^{th} percentile)
Norovirus infection, based on rates	2135	91	2226	873 (675-1083)
Campylobacteriosis	927	30	957	540 (385-730)
STEC infection	210	295	505	200 (1.5-783)
Listeriosis	8	180	188	160 (31-305)
Norovirus infection, based on rate ratios	219	91	310	122 (80-205)
Salmonellosis	97	15	112	67 (29-133)
Yersiniosis	109	2	111	62 (45-83)

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

The ranking order in Table 7 shows some changes from the ranking based on DALYs carried out in 2007 (Cressey and Lake, 2007). The current analysis concludes that norovirus contributes the greatest burden of disease, as measured by DALYs, of the six pathogens considered. However, this is critically dependent on the method used to calculate disease incidence and the non-application of the disability weight relevance criterion. The bulk of the burden associated with norovirus is due to the large number of relatively mild gastroenteritis cases.

STEC infection is ranked three places higher than in the earlier DALY ranking exercise. This is entirely due to the use of the IID2 multiplier, as the incidence of HUS and ESRD, subsequent to gastroenteritis, is indexed to the incidence of STEC infection.

3.4 Sensitivity of DALY Estimates to Different Disability Weight and Attribution Options

Table 8 summarises the impact of the relevance criterion and different attribution approaches on estimates of foodborne DALYs. It should be noted that neither of these factors impact estimates of foodborne DALYs for listeriosis. For concision, norovirus estimates are all based on the application of population rates.

Table 8: Impact of disability weights and attribution options on mean estimates of foodborne DALYs for selected microbial diseases in New Zealand

Disease	Foodborne DALYS			
	2005, no RC	2005, RC	2011, no RC	2011, RC
Norovirus infection (population rates)	207	11	873	94
Campylobacteriosis				
- Base case (attribution by EE)	1118	663	540	228
- Foodborne = poultry	1520	901	477	203
- Foodborne = P+0.25R	1595	946	549	234
- Foodborne = P+0.75R	1739	1032	690	294
STEC infection	38	37	200	193
Listeriosis	217	217	160	160
Salmonellosis	164	90	67	39
Yersiniosis	67	30	62	18

RC: relevance criterion
EE: expert elicitation (Cressey and Lake, 2005)
P+0.25R: foodborne transmission defined as all poultry source cases and 25% of ruminant source cases
P+0.75R: foodborne transmission defined as all poultry source cases and 75% of ruminant source cases

The application of the relevance criterion has the most marked effect on the estimated foodborne DALYs for norovirus infection. This is not surprising as the disease burden due to norovirus infection is mainly due to the large number of mild cases of gastroenteritis. With the application of the relevance criterion these cases are assigned a zero disability weight.

Application of the relevance criterion leaves campylobacteriosis as the highest ranked disease, followed by STEC infection and listeriosis.

Application of alternative attribution schemes for campylobacteriosis increases the 2005 estimates of foodborne DALYs, no matter which alternative scenario is considered. For the 2011 year, the base case (attribution based on expert opinion) produces an estimate of foodborne DALYs intermediate between defining foodborne as all poultry source cases and defining foodborne as all poultry source cases and 25% of ruminant source cases.

While it is not possible to say which of these attribution approaches is most accurate, it appears likely that the estimate of the proportion of campylobacteriosis that is foodborne derived from expert elicitation may have underestimated this proportion for 2005. However, no matter which attribution scheme is adopted, the relative ranking of campylobacteriosis on the basis of foodborne DALYs remains unchanged (i.e. always the top ranked in 2005 and the top ranked in 2011, if a relevance criterion is applied).

4 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, STEC infection, listeriosis, salmonellosis, and yersiniosis. The 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. However, the estimated burden of disease due to *Campylobacter* infections has decreased markedly with time. The ranking for STEC infection is dominated by the sequelae, HUS and ESRD. The ranking for listeriosis is based almost entirely on the number of perinatal fatalities, resulting in a large number of years of life lost.

If a relevance criterion is applied then norovirus infection drops to fourth ranked, with all other diseases maintaining the same relative ranking positions.

Using alternative approaches to define the proportion of campylobacteriosis cases that are due to foodborne transmission influences the absolute DALYs estimates for this disease, but does not influence its ranking relative to other diseases considered.

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 90% confidence 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 77 cases per year of HUS due to STEC infection, while in the 2011 year only 39 cases of HUS were reported to be hospitalised in New Zealand (Lim *et al.*, 2012).

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.

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APPENDIX 1 COMPARISON OF ESTIMATES OF THE INCIDENCE OF SELECTED FOODBORNE DISEASES AND DISEASE STATES BETWEEN 2005 AND 2011

Disease state	Incidence (mean cases per year, 90%CI)		Reason for difference
	2005	2011	
Campylobacteriosis			
GE, total	123,000 (89,000-170,000)	63,800 (43,000-90,000)	Reduced notifications
GE, no GP	81,000 (41,000-126,000)	55,000 (34,000-81,000)	Reduced notifications
GE, GP only	42,000 (37,000-46,000)	8,800 (6,400-11,500)	Reduced notifications Lower multiplier
GE, Hospitalisation	950 (710-1260)	574	Reduced hospitalisations
GE, Death	1.3 (0.4-2.3)	0.4 (0-2)	Reduced case mortality rate
GBS, total	28 (24-32)	36 (24-49)	Slight increase in GBS cases
GBS, mild	5.6 (4.5-6.6)	7.1 (3-12)	Slight increase in GBS cases
GBS, severe	23 (19-26)	29 (21-37)	Slight increase in GBS cases
GBS, death	1.0 (0.6-1.5)	1.3 (0-3)	Slight increase in GBS cases
ReA, total	3,200 (2,400-4,000)	660 (440-930)	Indexed to 'GE, GP only' figure
ReA, no GP	2,500 (1,800-3,250)	520 (340-750)	Indexed to 'GE, GP only' figure
ReA, GP	540 (200-950)	112 (37-208)	Indexed to 'GE, GP only' figure
ReA, Hospitalisation	135 (24-320)	28 (4-69)	Indexed to 'GE, GP only' figure
IBD, total	49	23 (16-32)	Reduced notifications
Salmonellosis			
GE, total	16,800 (5,800-29,800)	6,300 (1,600-15,500)	Lower multiplier
GE, no GP	12,400 (1,500-24,600)	4,700 (0-13,900)	Lower multiplier
GE, GP only	4,400 (3,500-5,700)	1,600 (700-3,000)	Lower multiplier
GE, Hospitalisation	159 (119-214)	135	Slightly reduced hospitalisations
GE, Death	2.4 (0.5-4.6)	0.6 (0-2)	Reduced case mortality rate
ReA, total	365 (184-582)	134 (47-277)	Indexed to 'GE, GP only' figure
ReA, no GP	288 (142-467)	105 (36-218)	Indexed to 'GE, GP only' figure

Disease state	Incidence (mean cases per year, 90%CI)		Reason for difference
	2005	2011	
ReA, GP	62 (19-122)	23 (6-54)	Indexed to 'GE, GP only' figure
ReA, Hospitalisation	16 (2-40)	5 (0-16)	Indexed to 'GE, GP only' figure
IBD, total	4	3 (1-7)	
Listeriosis (Perinatal)			
Sepsis	1.2 (0.7-1.9)	1.4 (0-3)	
Meningitis	0.4 (0.2-0.7)	0.5 (0-2)	
Pneumonia	1.2 (0.6-1.8)	1.2 (0-3)	
Death - perinatal - neonatal	 2.5 (1.4-3.8) 0.4 (0.2-0.7)	 1.8 (0-4) 0.1 (0-1)	
Neurological sequelae	0.2 (0.1-0.4)	0.3 (0-1)	
Listeriosis (Non-perinatal)			
Sepsis	4.9 (3.4-6.7)	7.0 (3-12)	
Meningitis	7.5 (5.5-10.1)	9.9 (5-15)	
Gastroenteritis	3.6 (2.4-5.1)	5.2 (2-9)	
Pneumonia	3.6 (2.4-5.1)	5.2 (2-9)	
Death	1.4 (0.5-2.3)	2.6 (0-6)	
Neurological sequelae	1.0 (0.8-1.4)	1.4 (0-4)	
STEC infection			
GE, total	340 (180-620)	2,830 (120-10,500)	Increased notifications Higher multiplier
GE, bloody	148 (96-202)	1,260 (52-4,680)	Increased notifications Higher multiplier
GE, non-bloody	192 (15-505)	1,570 (67-5,880)	Increased notifications Higher multiplier
GE, death	0.7 (0.2-1.5)	0.1 (0-1)	Reduced case mortality rate
HUS, clinical	9.3 (4.9-16.9)	77 (3-290)	Indexed to 'GE, total' figure
HUS, death	0.4 (0.2-0.8)	3.1 (0-13)	Indexed to 'GE, total' figure
ESRD	1.2 (0.6-2.2)	8.8 (0-35)	Indexed to 'GE, total' figure

Disease state	Incidence (mean cases per year, 90%CI)		Reason for difference
	2005	2011	
Yersiniosis			
GE, total	7,900 (5,700-10,400)	9,500 (7,000-12,300)	Increased notifications
GE, no GP	6,600 (4,500-9,000)	7,900 (5,400-10,700)	Increased notifications
GE, GP only	1,300 (1,200-1,450)	1,600 (1,500-1,650)	Increased notifications
GE, Hospitalisation	37 (30-41)	39	
GE, Death	0.5 (0.1-1.2)	0.1 (0-1.0)	Reduced case mortality rate
ReA, total	80 (15-150)	95 (57-140)	Indexed to 'GE, GP only' figure
ReA, no GP	63 (38-92)	75 (44-113)	Indexed to 'GE, GP only' figure
ReA, GP	14 (5-25)	16 (4-32)	Indexed to 'GE, GP only' figure
ReA, Hospitalisation	3 (1-8)	4.1 (0-11)	Indexed to 'GE, GP only' figure
Norovirus infection	**(based on applying rate ratios)**		
GE, total	403,000 (71,000-1,004,000)	20,800 (17,700-24,200)	Lower multiplier
GE, no GP	357,000 (43,000-942,000)	19,900 (16,800-23,300)	Lower multiplier
GE, GP only	46,000 (7,000-116,000)	930 (670-1,240)	Lower multiplier
GE, Hospitalisation	18 (10-27)	160	Increased hospitalisations
GE, Death	0.8 (0.2-1.4)	4.4 (1-8)	Increased case mortality rate
Norovirus infection	**(based on applying population rates)**		
GE, total	61,200 (51,900-70,900)	208,000 (178,000-242,000)	Higher multiplier
GE, no GP		199,000 (168,000-232,000)	
GE, GP only		9,400 (6,600-12,500)	
GE, Hospitalisation	18 (10-27)	160	Increased hospitalisations
GE, Death	0.8 (0.2-1.4)	4.4 (1-8)	Increased case mortality rate

90%CI: 90th percentile confidence interval

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