RISK RANKING: ESTIMATES OF THE COST OF FOODBORNE DISEASE FOR NEW ZEALAND

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by

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SUMMARY

This report contributes to a project with the following goal:

- The development of a single metric of risk ranking that can be applied to both chemical and microbiological hazards, and is applicable to the varied risk ranking needs of the NZFSA.

The first Objective of the 2007-2008 project is to update the disability adjusted life years (DALY) estimates, reported in 2006-2007, using new disability weights derived from studies being conducted by RIVM in the Netherlands. At the time of writing this December 2007 report these are not yet available, and this issue will be addressed later in the financial year.

The second Objective involves preparing estimates for the direct and indirect economic burden of gastrointestinal disease. These estimates are described as Cost of Illness (COI), and are an alternative metric to the DALY burden of illness for comparing the impact of food hazards.

The COI estimates represent a combination of the numbers of cases generated to produce the DALY estimates in 2006-2007, with unit costs. Case numbers are based on notifications and hospitalisations for the 2005 year. Unit costs are based on the most recent available information, which in most cases will be from 2006 or 2007. An exception is hospital pricing, for which the medical/surgical inpatient national price for 2007-2008 was combined with price weights from 2004-2005, to allow the price weights to align more closely to timeframe of the hospitalisation figures used in this study.

The total estimated cost to the New Zealand society due to foodborne transmission of disease directly or subsequently due to *Campylobacter, Salmonella, Listeria monocytogenes,* shiga toxin-producing *Escherichia coli, Yersinia enterocolitica* and Norovirus is estimated to be approximately $86 million, with approximately 90% of the cost due to lost productivity associated with people temporarily or permanently removed from the work force. Illness due to *Campylobacter* accounts for approximately 90% of the total estimated cost of foodborne illness. The highest costs per case were due to disease caused by *Listeria monocytogenes*.

1 INTRODUCTION

This report contributes to a project to rank the risks associated with hazards in food, with the following goal:

- To further develop a single metric of risk ranking that can be applied to both chemical and microbiological hazards, and is applicable to the varied risk ranking needs of the NZFSA.

From 2002 – 2005 the risk ranking project conducted by ESR for the NZFSA developed a process, and used expert opinion to produce disease severity and incidence estimates for a number of food/(microbiological) hazard combinations (Cressey and Lake, 2003; 2004a; b; 2005).

In 2006-2007, using a method largely based on previous work in the Netherlands (Kemmeren *et al.*, 2006), this project developed estimates for the burden of various foodborne diseases caused by microbiological hazards. These estimates were calculated in Disability Adjusted Life Years (DALYs) and provide one metric for ranking the risks associated with microbial foodborne diseases in New Zealand (Cressey and Lake, 2007).

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1.1 Cost Analysis Background

The total cost of illness can be considered in terms of three components; direct costs, indirect costs and intangible costs (BERL (Business and Economic Research Limited), 2002). 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. While intangible burdens can be assigned a monetary value under approaches such as willingness-to-pay (WTP) (BERL (Business and Economic Research Limited), 2002), the current study took the approach of Kemmeren *et al.* (2006) in considering only direct and indirect monetary costs as components of the cost of illness, while the intangible burden of foodborne microbial diseases was valued by the DALY method, as previously reported (Cressey and Lake, 2007).

For the current exercise, cost of illness will be taken to represent the burden of illness to individuals and society, in terms of expenditure resulting from the illness. These costs encompass both direct and indirect costs, including costs resulting from diagnosis and treatment of the illness, activities required to support diagnosis/treatment (e.g. travel to a doctor), and losses to society from lost productive activity.

In this context, cost analysis considers only the resources consumed as a result of disease. These may include costs to:

- The health sector;
- Other sectors;
- Patient/family;
- Productivity losses.

The first three of these costs are considered to be direct costs; the last is considered to be an indirect cost. The specific costs to be included in a cost of illness study are dependent on the viewpoint for the analysis; individual or societal. The societal viewpoint is the broadest view and has been adopted for the current study.

Two alternate estimations of costs are possible:

- Prevalence approach: stream of healthcare costs accruing to all patients alive during a specific time period;
- Incidence approach: discounted expected sum of current and future costs of all new cases occurring within a specified time period.

The incidence approach has been adopted for the current study. This is consistent with major recent studies carried out overseas to assess costs of foodborne illness (Abelson *et al.*, 2006; Kemmeren *et al.*, 2006).

1.2 Costs included in this analysis for New Zealand

In this analysis, we have taken a societal viewpoint, and included costs for:

- Direct health-care costs. This includes costs for GP consultations and medications (either over the counter (OTC) or prescription), even though a proportion of these may be paid for by some people themselves. There is a variety of subsidies for GP visits and medications, and we have not attempted to disentangle the components of this cost, and have instead allocated the entire cost to this category.
- Direct non-health-care costs. This consists of travel costs to and from a GP consultation or a hospital.
- Indirect non-health-care costs: costs to society due to lost production resulting from illness. We have only estimated costs due to lost production from work missed by employed people.

This approach was adopted to align the current study with that of Kemmeren *et al.* (2006), conducted in the Netherlands, to facilitate international comparability of COI studies for foodborne illness.

In a previous estimate of the costs of foodborne illness in New Zealand (Scott *et al.*, 2000) no distinction between paid and unpaid activities, and leisure activities, was made. In addition, the value of statistical lives lost (from a willingness-to-pay estimate) was included. We have assumed that the losses for unpaid activities, lost leisure time, and premature death, in terms of quality of life (not lost productive time), will be captured by the DALY estimates.

We have adopted a more restricted definition of these indirect non-health-care costs i.e. only lost productive time in paid activity for the ill person, or a care-giver. We have utilised data from the recent acute gastrointestinal illness (AGI) study (Adlam *et al.*, 2007) to estimate the proportion of cases who are in paid employment, and the number of days lost. For fatalities, we have also estimated lost production.

The specific costs included for each outcome of the illnesses are detailed in Section 3.

We have adopted an incidence approach to estimating these costs, estimating the current annual cost, as well as discounted future costs. The data used to estimate these costs is often based on averages from multiple recent years, and so year by year analysis is not possible.

1.3 Discounting

In economic analyses it is common to compare costs that occur over an extended time period in terms of their present value (Kemmeren *et al.*, 2006). Because immediate profit is generally preferred over future profit, future costs are discounted compared to present costs. The rate at which future costs are discounted is referred to as the discount rate and as the discount rate increases future costs decrease relative to present costs (Grocott *et al.*, 2007). A number of methods are available for estimating the discount rate. In New Zealand, PHARMAC have recommended using the five year average real risk-free long-term government bond rate (3.5%) and have additionally suggested that sensitivity analysis be conducted using rates at 0, 5 and 10% (Grocott *et al.*, 2007). These guideline were followed to assess model sensitivity to the discount rate.

Discounting is not relevant for costs associated with illnesses that have a duration of less than one year, but may have a substantial impact on health endpoints such as death or life-long disability (Kemmeren *et al.*, 2006).

2 ILLNESSES AND OUTCOMES

For this project, development of COI estimates for the following illnesses was agreed with the NZFSA:

- 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). Further details of the expert consultation are included in section 2.5.

The COI estimates were calculated by developing a model using @RISK software (Palisades Corporation). For many of the inputs needed for the calculations data were either variable or uncertain. The modeling approach taken allowed these inputs to be described by distributions, to encompass the uncertainty and variability in the estimates.

2.1 Outcomes

The adverse health outcomes resulting from these illnesses define the components of the COI 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).

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 illness.

The severity or duration of AGI is usually reflected in the actions taken by or for patients, and in occasional circumstances may result in death. We define the outcomes of AGI as:

- Self limiting – recover by themselves, do not visit GP.
- Visit a GP
- Hospitalised
- Death

In this study it was assumed that cases who were hospitalized would have previously presented to a GP. This was also the approach taken in the Dutch study (Kemmeren *et al.*, 2006). It has further been assumed that fatalities will have come from one of the other three categories.

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.

The specific outcomes included in the COI estimates for each illness are defined in the following sections. In general, these follow the approach used by Kemmeren *et al*. (2006).

2.1.1 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 cases of IBD made in this study are based on a New Zealand study (Gearry *et al.*, 2006), which classified cases of IBD as either Crohn's disease, ulcerative colitis or indeterminate colitis.

2.1.2 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

2.1.3 Listeriosis (perinatal)

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)

Due to a lack of information on liveborn listeriosis cases, the Dutch study based their DALY estimate for perinatal listeriosis only on deaths. The same approach was taken in the current study.

2.1.4 Listeriosis (acquired, non-perinatal)

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 for the current study:

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

2.1.5 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:

- Gastroenteritis with non-bloody diarrhoea
- Gastroenteritis with bloody diarrhoea
- Gastroenteritis with fatality
- Haemolytic uraemic syndrome (HUS)

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

2.1.6 Yersiniosis

This illness was not considered in the Dutch study. We consider that the same AGI outcomes will apply as for 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

2.1.7 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)

2.2 Life expectancy

The life expectancy of a case is used to calculate the duration of treatment for diseases that are considered to be lifelong (e.g. end stage renal disease, inflammatory bowel disease. The Demographic Trends 2006 report from Statistics New Zealand (http://www.stats.govt.nz/analytical-reports/dem-trends-06/default.htm) provides tables that show life expectancy for males and females at ages up to 90 years, for the years 2000-2002.

It has been assumed that, except in cases where individuals die from the diseases considered, the diseases considered in this report will not affect life expectancy.

2.3 Data from New Zealand Health Information Services (NZHIS)

A data request was submitted for hospitalised cases and mortality for the set of relevant ICD –10 codes. The most up to date data were obtained: 2000 – 2006 (hospitalisations) and 2001 – 2004 (mortality). The data request included cases where the ICD code occurred anywhere in the first 20 diagnosis codes.

In most cases matching of disease states of interest with ICD-10 code was straightforward. The major exception was reactive arthritis, for which there is no specific ICD-10 code. The codes matched to this disease were selected after consultation with specialists (see Appendix 2).

To determine the number of cases in a year for each illness from the NZHIS data, readmissions within the same calendar year were removed.

2.4 Timeframe

The intention in developing these estimates was to describe the burden of illness using the most recent data. Inevitably the years for which the most recent data were available varied amongst the data required. It was also felt to be important to make the timeframe consistent with the previous DALY estimates (Cressey and Lake, 2007). Therefore, case numbers were based on notification and hospitalizations for the 2005 year.

A second consideration was that 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. Mortality figures were not available from NZHIS for the 2005 year. Data from 2001-2004 were used to describe the mortality rate for each disease as a Gamma distribution, with was used to estimate a Poisson distribution for the expected number of fatalities in the 2005 year.

NZHIS morbidity and mortality data from the complete year range available and notification data from 2000-2005 were used to calculate the age distribution for incident cases, hospitalized cases and fatal cases.

2.5 Attribution: Percentage Foodborne

The proportion of the COI 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 expert consultation was conducted as a modified double pass Delphi, with facilitating discussion carried out between the first and second pass. Experts in the area of food microbiology and foodborne disease epidemiology were asked for their opinion of the proportion of disease due to various microbial pathogens that was due to transmission via food. For each pathogen each expert was asked for the minimum (‘at least’), the most likely and the maximum (‘not more than’) proportion of the disease that may be due to foodborne transmission. The mean values for the expert estimates of minimum, most likely, and maximum were treated as a Pert distribution for modeling purposes. The Pert distribution was used in preference to the triangular distribution, which

has the same parameters, because the triangular distribution tends to overweight the contribution of the tails of the distribution to the overall mean (Vose, 2000). The relevant data for the illnesses being considered are given in Table 1. Results in Table 1 are from the second pass.

Table 1: Proportion of disease due to foodborne transmission – summary of expert opinion, May 2005 (Cressey and Lake, 2005)

Disease	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

3 COSTS INCLUDED: OVERVIEW FOR ILLNESS OUTCOMES

For each of the illness outcomes listed in Section 2 there are associated costs, which when multiplied by the number of cases and added together comprise the overall cost of illness.

A summary of the outcomes, associated costs and data sources is given below.

AGI:

- AGI (do not visit a GP and recover)
    - Over the counter medications (and other related necessities)
    - Travel to and from purchase of medications
    - Cost of lost productive time (for the case and any associated caregivers)
- AGI (visit a GP and recover)
    - Cost of GP consultation
    - Travel to and from GP
    - Prescription medicine
    - Cost of lost productive time (for the case and any associated caregivers)
    - Diagnostic laboratory testing
- AGI (hospitalised and recover)
    - Hospital costs (aggregated in a DRG cost)
    - Travel to and from hospital
    - Cost of lost productive time (for the case and any associated caregivers)
- AGI (death)
    - Cost of lost productive time

It is assumed that all hospitalized cases will have attended a GP and their illness costs prior to hospital admission will be captured in the category 'AGI (visit a GP and recover)'. It has further been assumed that fatalities will have come from one of the other three categories and prior medical costs will be accounted under that category.

Sequelae

We make the assumption that each sequela includes a preceding episode of AGI that is included in one of the three categories (do not visit a GP, visit a GP, and, hospitalised) above. Sequelae from AGI vary considerably in their consequences, but the costs considered may include:

- Additonal cost of GP and specialist consultations
- Hospital costs
- Treatment costs (medication, diagnostic testing)
- Rehabilitation costs
- Cost of lost productive time (for the case and any associated caregivers)

4 DIRECT HEALTH CARE COSTS (DHC)

As the current study looks to determine to cost to New Zealand of foodborne disease, all identifiable transfer payments were excluded from the analysis of costs. This means that all prices included in this and later sections are exclusive of GST.

4.1 General Practitioner Consultations

The Consumer Price Index for the June 2007 quarter gave the weighted average retail price for 'General Practitioner – consultation, adult without community services card' as $37.18. http://www.stats.govt.nz/NR/rdonlyres/A18989BE-7843-4F89-9F8D-43CFB330FADB/19716/cpijun07alltables.xls

Surveys carried out in 2004 (CBG, 2004) and 2005 (Hutton, 2005) demonstrated a wide range of GP fees being charged. However, these references only consider the private contribution to GP fees (the consumer 'price'). On average, the total cost of a GP visit, including Government subsidies, has been reported to be approximately $50 (Grocott *et al.*, 2007). This figure was used for the current analysis.

The number of AGI and ReA cases attending a GP has been estimated previously (Cressey and Lake, 2007). For the serious sequelae (GBS, IBD, HUS, ESRD) it has been assumed that all cases will attend a GP, usually as a prelude to hospital admission or referral to a specialist for diagnosis.

Abelson *et al*. (2006) assumed six follow-up GP visits following hospitalization for GBS. Mangen *et al.* (2004) based their cost of illness calculations on subsequent neurologist consultation, physiotherapy visits and rehabilitation consultations. The latter approach was adopted for the current study.

Mangen *et al.* (2004) adopted a similar approach for estimating costs due to IBD, with a single GP consultation and subsequent medical consultations being conducted by a specialist gastroenterologist.

For HUS, Abelson *et al*. (2006) also assumed that two GP visits and a specialist referral would occur after hospital discharge. This assumption has been adopted for the current study.

The costs of ESRD were not considered by the other reference studies mentioned above. It has been assumed that consultations following the initial referral will be with specialists rather than GPs.

4.2 Hospital Treatment – Inpatient and Daypatient

The number of cases hospitalised due to AGI and ReA have been estimated previously (Cressey and Lake, 2007). In the current study it was assumed that all cases of GBS, HUS and ESRD would be hospitalized at some stage. Mangen *et al.* (2004) reported that in a case series, 38/300 ulcerative colitis (UC) cases and 39/150 Crohn's disease (CD) cases were admitted to hospital. The New Zealand study of Gearry *et al*. (2006) was used to calculate the numbers of UC and CD cases amongst the estimated IBD cases. The data from Mangen *et al*. (2004) were used to calculate beta distributions for the probability of a case of UC or CD

being hospitalized. The estimated number of hospitalized cases was then modeled as a binomial distribution.

4.2.1 Costs

Unit prices for hospital admissions were derived from diagnosis related group (DRG) costings. DRG costings are a case-mix classification system in which cases with similar costs are categorized within broader groupings relating to the same or similar organ or body system. This is the same approach as that adopted for an Australian assessment of the costs of foodborne disease (Abelson *et al.*, 2006).

Each hospitalized case is assigned to a DRG code based on:

- Diagnosis
- Procedures
- Sex
- Age
- Event end type
- Length of stay
- Leave days
- Admission weight
- Mental health legal status
- Same-day status

Each DRG code is assigned a weighted average price, based on the medical/surgical inpatient national price and the price weight for the individual DRG code in the year of interest. The latest published average price weight information for New Zealand is from the 2004/2005 year:
http://www.moh.govt.nz/moh.nsf/indexmh/hospital-throughput-0405?Open
This is consistent with the timeframe for the case numbers used in this study. The most recent available medical/surgical inpatient national price is for the 2007-08 year ($3,740.38):
http://www.nzhis.govt.nz/moh.nsf/pagesns/300/$File/Wies11c-final+160307.doc
This is consistent with the practice used in this study of using the most recent available unit cost figures.

For diseases and sequelae resulting from foodborne micro-organisms, cases may be admitted to hospital on one or more occasions and may experience different procedures after admission, depending on the particular case. Public hospital discharge data, obtained from the New Zealand Health Information Service (NZHIS) were used to determine the distribution of the number of times admitted, and the DRG code assigned to admissions for ICD-10 diagnosis codes of relevance to foodborne illness. Information on numbers of admissions per case are shown in Table 2.

The main DRG codes associated with ICD-10 primary diagnosis codes and the frequencies with which they are associated are given in Appendix 1. It should be noted that for inflammatory bowel disease hospital admissions will include day patient admissions for diagnostic procedures such as colonoscopy.

Hospitalisation costs per case were calculated from the mean number of admissions per disease type and the weighted mean price for DRG codes associated with admissions for that disease type (Appendix 1).

Table 2: Frequency of number of admissions for principal foodborne illness associated diagnosis code (principal diagnosis only), 2000-2006

Condition	ICD10 code	Weighted mean, number of admissions/case	Percentage of cases admitted on x occasions					
			1	2	3	4	5	>5
Campylobacter enteritis	A04.5	1.05	96.4	3.1	0.3	0.1	0.06	0.08
Salmonella enteritis	A02.0	1.05	96.1	3.5	0.2	0.0	0.1	0.1
STEC infection	A04.0-A04.4	1.05	95.1	4.9	0.0	0.0	0.0	0.0
Yersinia enteritis	A04.6	1.07	97.0	2.0	0.0	1.0	0.0	0.0
Norovirus gastroenteropathy	A08.1	1.20	87.0	10.9	0.0	0.0	2.2	0.0
Reactive Arthritis	M02.1, M02.3, M02.8, M02.9, M46.9	1.34	84.7	4.9	7.4	1.0	0.0	2.0
Guillain Barré Syndrome	G61.0	2.35	67.6	16.1	7.6	3.4	1.8	3.4
Inflammatory Bowel Disease	K50, K51	2.40	54.5	18.1	10.6	5.9	3.4	7.6
Haemolytic Uraemic Syndrome	D59.3	2.27	50.0	28.2	15.4	1.3	0.0	5.1
End Stage Renal Disease	N18.0	4.07	40.8	15.5	9.2	6.7	4.9	22.9
Listerial meningitis	A32.1	1.49	77.1	11.4	2.9	2.9	5.7	0.0
Listerial septicaemia	A32.7	1.19	76.5	17.6	0.0	0.0	0.0	5.9
Listeria, other	A32.8, A32.9	1.33	77.8	11.1	11.1	0.0	0.0	0.0

The data received from the New Zealand Health Information Service did not allow identification of mild and severe cases of GBS. For the current study, hospital costs associated with GBS cases were applied equally to estimates of the number of mild and severe cases. While the hospital costs assigned to mild and severe cases will be over and under-estimates respectively, the total hospitalization costs due to GBS should be approximately correct.

4.3 Outpatients, Specialists and non-Laboratory Diagnostic Procedures

No corresponding data source is available for outpatient throughput and pricing to that outlined in section 4.2 for inpatient and daypatient treatment. Several of the sequelae included in the current study will require outpatient services for diagnosis and treatment e.g. GBS, IBD, ESRD. However, typical values for outpatient services can be derived by reference to medical cost rates published by health insurers. Data sources include:

- Southern Cross Healthcare (http://www.southerncross.co.nz/) (July 2007)
- UniMed (http://www.unimed.co.nz/about.html) (April 2006)

Based on information from these sources a specialist consultation would cost in the range $60-125.

Physiotherapy costs were based on the 2007 ACC purchase rate of $21.76 per treatment (http://www.dol.govt.nz/consultation/physiotherapy/acc-final-report.pdf). Providers may also charge co-payments, which were found to average $14.26 per initial consultation and $9.73 for a follow up consultation. For the current study physiotherapy costs per treatment were modelled as a uniform (21.76, 36.12) distribution.

In addition to diagnostic laboratory testing a range of other diagnostic procedures may be necessary, particularly for diagnosis of sequelae. Typical medical imaging costs were based on those of the Christchurch Radiology Group (http://crg.co.nz/).

It has been assumed that no outpatient or medical specialist costs will be associated with cases of acute gastrointestinal illness.

4.3.1 Reactive arthritis

Mangen *et al*. (2004) modelled the costs of ReA, based on a specialist rheumatologist attending cases hospitalised with ReA. In the current model these costs would be included under the hospital costs and no separate costs for specialist, outpatient and other diagnostic testing have been assigned for ReA in the current exercise.

4.3.2 Guillain-Barré syndrome

Diagnosis of GBS may be achieved by physical examination and symptoms. The GBS New Zealand website reports this to be the most common route of diagnosis (http://www.gbsnz.org.nz). However, the diagnosis may be confirmed by a lumbar puncture and electrical tests (electromyography). In New Zealand, these tests are usually performed following hospital admission and will be included in hospitalization costs.

For other specialist and outpatient costs following discharge we have adopted the approach of Mangen *et al.* (2004).

For mildly affected cases:

- 60-75% of cases would require physiotherapy for approximately twelve weeks, with either one, two or three (equal probabilities) consultations per week. Travel to and from the physiotherapist was costed using the same distances as for a GP visit.
- 5% of cases would need an additional nine physiotherapy consultations.
- Two additional neurologist consultations for all cases. Travel was costed using the same distance as for a hospital visit.

For severely affected cases:

- Three additional neurologist consultations for all cases.
- Referral to a rehabilitation centre. In New Zealand, this rehabilitation function appears to be carried out in the hospital environment and will be included in hospitalization costs.
- Physiotherapy for six months to two years at the rate of one consultation per week, depending on F-score at discharge. For the current study the figure of Mangen *et al.*

(2004) were used to assign severely affected GBS cases to F-score classes and duration of physiotherapy.

4.3.3 Inflammatory bowel disease

In New Zealand, treatment for IBD appears to be either through medication or surgical intervention (see: http://www.ccsg.org.nz, http://www.crohnsandcolitis.org.nz/). It is assumed that all IBD patients will be referred to a gastroenterologist at some point and will continue to see the specialist at intervals for the duration of their illness. Based on an average of two specialist consultations per annum and the age distribution of incident cases, the total number of specialist visits associated with IBD cases was calculated. Travel costs were also calculated for each specialist visit, assuming that the specialist would be associated with a hospital location.

Medical imaging may also be used to aid diagnosis and specifically to exclude obstructions as a cause of observed symptoms. One x-ray cost per patient has been included in the current study.

4.3.4 Haemolytic uraemic syndrome

In line with the approach of Abelson *et al*. (2006) it was assumed that each HUS case would experience follow-up of two GP visits and one specialist visit.

4.3.5 End stage renal disease

ESRD patients will require dialysis prior to kidney transplantation and during periods between graft rejection and subsequent transplantations. For the current study it was assumed that haemodialysis would be performed on an outpatient basis three or four times per week (uniform distribution). The cost of haemodialysis was taken from the Christchurch Hospital Nephrology Department website ($577.78; http://www.cdhb.govt.nz/nephrology/dialysis.htm). It was further assumed that each haemodialysis event would incur additional costs of return travel to a hospital.

It was further assumed that ESRD patients would see a nephrologist every three months for the duration of their lives. Costs of kidney transplantations and other serious complications will be included under hospitalization costs.

While discounting should be applied to these costs, as they will continue beyond the year in which the disease first occurs, the situation is complicated by the fact that dialysis may occur at irregular intervals (e.g. prior to transplantation, after graft rejection), rather than occurring continuously. For the purpose of this study it has assumed that years spent on dialysis are contiguous and immediate follow the onset of disease. Specialist's fees were also discounted.

4.4 Medication

4.4.1 Usage – acute gastrointestinal illness

While New Zealand specific data on medication usage due to acute gastrointestinal illness (AGI) due to various microbial diseases are not available, information on medication usage for general cases of AGI is available from the recently complete AGI Community Study

(Adlam *et al*., 2007). Table 3 summarises results on consultation of medical professionals and use of medication from the AGI Community Study.

Table 3: Rates of consultation of medical professional and use of medication for cases of acute gastrointestinal illness in New Zealand

Category	Number of cases (percent)	
Acute Gastrointestinal illness in previous four weeks	296	
Consulted medical professional	No	191 (64.5)
	Yes, any	105 (35.5)
	Yes, GP	65 (22.0)
	Yes, Pharmacist	41 (13.9)
	Yes, Nursing services	23 (7.8)
	Yes, Alternative healthcare	17 (5.7)
	Yes, A/H clinic	13 (4.4)
	Yes, Healthline	12 (4.1)
	Yes, A&E	6 (2.0)
Any medication - Consulted medical professional - Didn't consult medical professional	61/105 (58.1) 52/191 (27.2)	
Anti-diarrhoeal - Consulted medical professional - Didn't consult medical professional	19/105 (18.1) 10/191 (5.2)	
Anti-nausea - Consulted medical professional - Didn't consult medical professional	18/105 (17.1) 2/191 (1.0)	
Anti-biotics - Consulted medical professional - Didn't consult medical professional	21/105 (20.0) -	

The AGI Community Study did not specifically ask about the use of analgesics or oral rehydration products (Adlam *et al.*, 2007). The COI study of Mangen *et al*. (2005) reported that 31% of *Campylobacter*-associated AGI cases not visiting a GP and 59% of cases visiting a GP used analgesics. These figures are very close to the figures for use of any medication in the AGI Community Study (27.2% and 58.1% of cases visiting a GP and not visiting a GP, respectively). For the current COI study, it will be assumed that a report of 'any medication used' in the AGI Community Study can be interpreted as 'at least using over the counter analgesics'. Mangen *et al.* (2005) reported that 5% of *Campylobacter*-associated AGI cases not visiting a GP and 33% of cases visiting a GP used oral rehydration products. In the absence of New Zealand specific data these figures will be used for all microbial AGI cases in the current study.

Data in Table 5 were used to determine the proportion of community AGI cases who would incur travel costs due to making a pharmacy visit to purchase over-the-counter medications. These data were also used to determine the proportions of community and GP-visit cases who

would use different types of medication. It was assumed that usage of different medications was not mutually exclusive, that is, a patient attending a GP may end up using any combination of analgesics, oral rehydration, antidiarrhoeal, anti-nausea and antibiotic medications.

4.4.2 Usage – reactive arthritis

Locht and Krogfeldt (2002) reported use of analgesics by 67% of cases with ReA, although the authors acknowledged that this was probably an overestimate. Mangen *et al.* (2004) excluded medication costs from their cost of illness estimates for ReA resulting from *Campylobacter* infection. In the current study it was assumed that ReA cases not attending a GP would not require medication, while for hospitalised cases medication costs would be included in the costs of hospital treatment. For ReA cases attending a GP it was assumed that analgesic use would be likely in a proportion of cases. This proportion is uncertain and was modelled as a uniform distribution between 0 and 67%.

4.4.3 Usage – Guillain-Barré syndrome

While it is quite likely that GBS cases may use some medication, neither of the exemplar cost of illness studies consulted included medication costs for this condition (Abelson *et al.*, 2006; Mangen *et al.*, 2004) and none have been included for GBS in the current study.

4.4.4 Usage – inflammatory bowel disease

Treatment options for IBD include a range of medications as well as surgical intervention (Ward *et al.*, 1999). Medication options include *d*-amino salicylic acid derivatives, corticosteroids and immunosuppressive agents. Amino salicylic acid derivatives appear to be the frontline medication for IBD in New Zealand (Fraser, 2003) and for the current study it has been assumed that IBD patients will be prescribed either Pentasa (2 g/day)or Asacol (1.6 g/day). At this rate the daily costs of these medications, based on the Pharmac schedule, are nearly identical ($2.76 and $2.74/day). Mangen *et al.* (2004) based their proportion of IBD patients medicated on a review of 272 German cases of IBD that reported prescription of medication in approximately 93% (255/272) of cases. This figure was used in the current study.

4.4.5 Usage – haemolytic uraemic syndrome

No reference was found to treatment of HUS with prescription medicine.

4.4.6 Usage – end stage renal disease

While medication (antibiotics, stomach acidity regulators) may be required to treatment side effects due to deteriorating renal function, these costs have not been included in the current exercise.

4.4.7 Costs

Analgesics: Costs of over-the-counter analgesics vary, depending on brand and pack size. A visit to a local supermarket indicated that the costs are likely to be in the range $3-6 and for the current exercise the cost of analgesics was modeled as a uniform(3,6) distribution.

Costs of prescription medications were derived from the Pharmac schedule of prescription medicines and other products subsidized by the government (http://www.pharmac.govt.nz/schedule.asp).

4.5 Laboratory Testing

Laboratory testing may be used to support diagnosis of acute gastrointestinal illness or associated sequelae.

4.5.1 Usage – acute gastrointestinal illness

For acute gastrointestinal illness, the proportion of cases classified as laboratory confirmed were assigned costs associated with a faecal culture for enteric pathogens. In the case of laboratory confirmed norovirus cases it was assumed that a faecal culture and a PCR test for norovirus would have been carried out.

4.5.2 Usage – reactive arthritis

The following diagnostic test have been applied to the diagnosis of ReA and the exclusion of alternative diagnoses (Toivanen and Toivanen, 2004); erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), blood leukocyte count, rheumatoid factor (RF), liver function test, urine and blood cultures. It was assumed that these tests would be carried out for all cases attending a GP. However, this is likely to be an overestimate, as this panel represents a comprehensive diagnostic response to the symptoms of ReA, while GPs will vary in their response to the symptoms.

4.5.3 Usage – Guillain Barré syndrome

No routine laboratory tests were identified for diagnosis of GBS.

4.5.4 Usage – inflammatory bowel disease

Mangen *et al*. (2004) reported that a faecal culture would usually be carried out as an initial step in the diagnosis of IBD. It was assumed in the current study that all IBD cases attending a GP would have a faecal culture test carried out. Other diagnostic procedures (e.g. colonoscopy with biopsy) would be carried out as daypatient procedures and would be included under hospitalization costs.

4.5.5 Usage - haemolytic uraemic syndrome

HUS cases are assumed to be admitted to hospital following a GP consultation. A number of diagnostic tests will be carried out in hospital, but the costs of these tests will be included in hospital costs. For patients discharged without residual effects, Abelson *et al.* (2006) assumed a follow up of two GP and one specialist visit, with laboratory testing including full blood count, erythrocyte sedimentation rate, creatinine and electrolytes.

4.5.6 Costs

The costs of laboratory tests vary to some extent between different laboratory providers. For the current cost of illness exercise, the cost of a diagnostic test was taken as the arithmetic mean of a 'basket' of published test prices. The sources of these test prices were:

- LabPlus, Auckland (http://www.labplus.co.nz/);
- Aotea Pathology, Wellington (http://www.apath.co.nz/); and
- Canterbury Health Laboratories, Christchurch (http://www.cdhb.govt.nz/chlabs/)

It was assumed that any diagnostic testing carried out while cases were hospitalised would be included under the costs of hospitalisation.

5 DIRECT NON-HEALTH CARE COSTS (DNHC)

5.1 Travel to and From Doctors or Hospital

5.1.1 Distance and time to doctor

Brabyn and Gower (2003) used New Zealand Census data (1996) and GIS analysis to estimate the traveling distance to the nearest general practitioner for the New Zealand population (Brabyn and Gower, 2003). Table 4 shows the output of this analysis, segmented by District Health Board.

Table 4: Summary of distance and time to GP for District Health Boards

District Health Board	Population (1996)	Population per GP	Average population distance to GP (km)	Average population time to GP (minutes)
Northland	136,515	1,128	9.56	11.7
Waitemata	394,059	1,327	2.19	3.2
Auckland	346,551	871	0.94	1.7
Counties Manukau	312,744	1,284	3.16	3.9
Waikato	312,744	1,298	4.93	6.1
Bay of Plenty	163,665	1,177	4.29	5.3
Lakes	95,103	1,235	5.24	6.4
Tairawhiti	45,999	1,353	7.05	8.3
Taranaki	106,917	1,353	3.83	4.6
Wanganui	67,593	1,379	5.56	6.9
MidCentral	157,911	1,436	4.64	5.4
Hawke's Bay	142,692	1,297	4.82	5.7
Wairarapa	38,508	1,540	5.58	6.7
Hutt Valley	132,852	1,510	1.68	3.0
Capital and Coast	234,615	1,096	1.31	2.3
Nelson-Marlborough	116,721	1,216	5.63	6.8
West Coast	32,502	1,625	16.28	16.6
Canterbury	411,150	1,052	2.57	3.2
South Canterbury	54,255	1,466	7.39	8.2
Otago	173,058	1,055	4.41	5.5
Southland	111,351	1,428	7.26	8.7
Population Weighted Average		**1,219**	**3.82**	**4.8**

For each of the notifiable diseases considered in this study the distribution of cases across DHBs was used to calculate a weighted average distance to GP for that disease. For norovirus, it was assumed that cases would be uniformly distributed across the country. It was further assumed that the distance to the nearest pharmacy would be approximately the same as the distance to the nearest doctor, but that cases attending a doctor and prescribed medication would obtain the medication during the same trip and would incur no additional travel costs.

5.1.2 Distance and time to hospital

Brabyn and Skelly (2002) carried out a similar analysis to that outlined in Section 5.1.1 to determine New Zealanders' access to public hospital (Brabyn and Skelly, 2002). However, results were only expressed on a time basis, with the national average travel time to the nearest public hospital being report as 17.9 minutes. Assuming that the ratio of time to distance reported for access to GPs is applicable to hospital access, a travel time of 17.9 minutes would equate to a travel distance of 14.2 km. This figure was used in the current exercise as the national average distance that a New Zealander must travel to reach their nearest public hospital.

5.1.3 Distance to other medical specialists

It was assumed that most medical specialists would be accessed through hospital outpatient departments or would be distributed in the community in a similar manner to hospitals. The exception to this is physiotherapists, many of whom are in private practice or are located at community medical facilities. It was assumed that travel distances to physiotherapists would be similar to travel distances to GPs, while distances to other specialists would be equivalent to travel distance to hospitals.

5.1.4 Travel costs

It was assumed that, in New Zealand, the majority of people would travel to doctors, pharmacies or hospitals by private motor vehicle. The total costs of running a motor vehicle include a number of fixed and variable costs, including, depreciation on the capital value of the vehicle, relicensing, insurance, warrant of fitness, fuel, and repair and maintenance. Within New Zealand, estimates of the average cost per kilometre have been estimated by the Inland Revenue Department and by the Automobile Association.
http://www.ird.govt.nz/business-income-tax/expenses/mileage-rates/
https://www.aa.co.nz/motoring/Section?Action=View&Section_id=574

For a standard petrol-fuelled motor car, the Inland Revenue rate is 62 cents per kilometre, while the Automobile Association rate is 78 cents per kilometre. The Inland Revenue rate has been largely unchanged for a number of years, while the Automobile Association rate is updated annually. The Automobile Association mileage rate was used for the current exercise.

Each GP or hospital visit was considered to be a return journey, with the total distance travelled being twice the distance from the cases home to the GP or hospital. Travel costs associated with people visiting the case while in hospital were not included.

6 INDIRECT NON-HEALTH CARE COSTS

6.1 Productivity Losses

Productivity losses due to disease are the main component of the indirect costs. Productivity losses may result from reduced participation in the workforce or reduced productivity while in the workforce due to disease (BERL, 2002). Two major methodologies have been applied in cost of illness studies to calculating the costs associated with these productivity losses; the Human Capital Method (HCM) and the Friction Cost Method (FCM).

6.1.1 Human capital method (HCM)

Under this method, indirect costs are equated to the production that would have been produced in the absence of the disease. This includes the loss of productive life years due to fatal disease outcomes. Losses are represented by the discounted future income foregone by the individual. Discounting is applied because the future value of capital is less than the current value.

This method treats the individual as a valuable economic resource whose removal, temporarily or permanently reduces the total human capital available to the economy, hence reducing the ability of the economy to produce goods and services.

This method was used for a recent Australian estimate of the annual cost of foodborne illness (Abelson *et al.*, 2006).

6.1.2 Friction cost method (FCM)

The FCM proposes that actual production losses due to illness will be limited by reactive mechanisms in the labour market, such as reallocation of tasks or replacement of individuals who are no longer able to work. Under this method, the maximum production losses are the temporary production losses associated with a short term absence or the period required to replace an individual who becomes permanently absent. Recruitment and training costs may also be included if the individual is unable to continue in employment.

The FCM produces much lower estimates of indirect costs than the HCM. The friction period will be a function of the labour market, with longer friction periods in situations of low unemployment.

This method was used for a recent Dutch estimate of the cost of selected foodborne diseases (Kemmeren *et al.*, 2006).

6.1.3 Selection of method

Several recent cost of illness exercises in New Zealand have noted that, with New Zealand's current low level of unemployment, the HCM is a more appropriate model for productivity losses due to illness or injury (Access Economics, 2005; BERL (Business and Economic Research Limited), 2002).

6.1.4 Remuneration

Daily income is frequently used in economic analyses as a proxy for the value of output associated with a day's work. Statistics New Zealand periodically collects information on the average income for New Zealanders (http://wdmzpub01.stats.govt.nz/wds). Information from their 2006 survey is summarized in Table 5. No distinction between different regions has been made.

Table 5: Income by age group for New Zealanders

Age group (years)	Average weekly income ($)	Average hourly income ($)*	Median weekly income ($)	Median hourly income ($)*
15 to 19	147	3.68	45	1.13
20 to 24	438	10.95	441	11.03
25 to 29	611	15.28	614	15.35
30 to 34	719	17.98	659	16.48
35 to 39	791	19.78	671	16.78
40 to 44	804	20.10	675	16.88
45 to 49	827	20.68	700	17.50
50 to 54	799	19.98	680	17.00
55 to 59	744	18.60	605	15.13
60 to 64	598	14.95	451	11.28
65+	403	10.08	303	7.58
Total	667			

* Based on pro rata of weekly income, based on a 40 hour week

In the current study, the age distribution of notified cases 15 years or older for the 2005 year, was combined with the average weekly income values in Table 4, to produce an average daily income (assuming a 5 day working week) for each illness. For cases of infection with norovirus (where notified cases data are not available) the average daily income calculated for campylobacteriosis cases was used.

Note that for cases younger than 15 years, or older than 65 years, it is assumed that no productivity losses are incurred by the case for the illness period. Productivity losses for carers were calculated for gastrointestinal illness. However, no information was found to calculate productivity losses due to carer absences from the work force for sequelae.

6.2 Duration of Illness

While for DALY calculation the key variable is the total duration of illness, this is less important for calculations of the cost of illness. The key variable are:

- The length of time away from work; and
- The length of time hospitalized (if applicable)

6.2.1 Length of time away from work – acute gastrointestinal illness

The AGI Community Study elicited information on time spent away from work for individuals with AGI from any source (Adlam *et al.*, 2007). Of the 296 AGI cases, 266 (90%) reported loss of time at work, school or recreation. Recreational activities were affected in 50% of cases for a mean duration of 3.8 days. Work was missed by 23% of cases (mean 3.1

days), and school/preschool/other educational activity was missed by 15% of cases (mean 3.5 days).

A third of all cases (36.4%) reported missed work time for either themselves (23%) or another person (13.5%). Of the 296 cases of gastroenteritis 163 were in paid employment. In this employed group acute gastroenteritis caused missed work in two thirds (66%) of cases for a mean duration of 3.1 days. See Table 6 for details.

Table 6: Missed paid work because of AGI

	Raw Sample (n=296)		
Details of person missing work	**No of cases**	**% of all cases**	**% of all paid worker cases (n=163)**
Cases missed paid work themselves	68	23.0	41.7
Other person missed paid work to care for case.	40	13.5	16.7
Total cases causing missed paid work	**108**	**36.4**	**66.3**

Note 1 Number with AGI, employed for last 4 weeks and >15 years = 163
Note 2 Weighted by age, sex and Maori/ non-Maori status
Note 3 Case definition "AGI" – vomiting and/or diarrhoea in the 4 weeks prior to interview, non infectious excluded

The previous work on the burden of foodborne illness in New Zealand classified cases on the basis of whether they attended a GP or not (Cressey and Lake, 2007). Data from the AGI study can be subdivided in terms of whether or not the individual sought help from a medical professional, as a surrogate for GP attendance. For those attending a medical professional, 37/48 (77%) reporting missing work, for an average of 4.34 days. For those not attending a medical professional, 31/115 (27%) reported missing work, for an average of 1.53 days.

For all cases who attended a medical professional (105 cases) a second person missed paid work to care for them in 27 cases (26%) for an average of 2.7 days. For cases not attending a medical professional (191 cases) a second person missed paid work to care for them in 13 cases (6.8%) for an average of 1.3 days.

These figures relate to AGI in general and do not provide any information on AGI due to different micro-organisms. Kemmeren *et al*. (2006) derived separate estimates for the number of days of work lost due to AGI for *Campylobacter*, *Salmonella*, and norovirus. Table 7 lists these separate estimates and compares them to estimates for general AGI in New Zealand.

Table 7: Comparison of different estimates of working days lost due to acute gastrointestinal illness

Causal Organism	**Days of paid work lost due to illness**			**Source of data**
	Cases not attending a GP	**Cases attending a GP**	**Cases hospitalized**	
Case				
Campylobacter	2.3	7.9	12.6	(Kemmeren *et al.*, 2006)
Salmonella	0.49	2.06	5.73	(Kemmeren *et al.*, 2006)

Causal Organism	Days of paid work lost due to illness			Source of data
	Cases not attending a GP	Cases attending a GP	Cases hospitalized	
Norovirus	0.33	0.8	2.56	(Kemmeren *et al.*, 2006)
General AGI	1.5	4.3		(Adlam *et al.*, 2007)
Caregiver				
Campylobacter	2.3	7.9	12.6	(Kemmeren *et al.*, 2006)
Salmonella	1.29	2.48	3.76	(Kemmeren *et al.*, 2006)
Norovirus	0.88	1.33	1.68	(Kemmeren *et al.*, 2006)
General AGI	1.3	2.7		(Adlam *et al.*, 2007)

Given that *Campylobacter*, *Salmonella* and norovirus are likely to be major contributors to the total burden of AGI in New Zealand, the data in Table 7 are reasonably consistent between the two studies referenced. For the current cost of illness study the probability of a case or a carer missing paid work will be taken from the New Zealand AGI study (Adlam *et al.*, 2007) and applied equally to all instances of AGI. The number of days of paid work missed by the case or an associated carer for *Campylobacter*, *Salmonella* and norovirus will be taken from the study of Kemmeren *et al.* (2006). The proportion of hospitalized cases and associated caregivers in paid employment was assumed to be the same as the proportion of cases attending a GP in the AGI study who were in paid employment.

AGI due to infection with *Yersinia enterocolitica* is considered to have a long duration compared to other common sources of infection. However, a Norwegian study of 67 laboratory-confirmed cases reported a total of 292 days lost from work or school during the acute phase of the disease (Ostroff *et al.*, 1992). This equates to 4.36 days per case, which is very similar to the days of work lost for a general AGI case in New Zealand who had sought medical aid (Table 7). Therefore, the New Zealand figures for general AGI in New Zealand were used in determining the cost of productivity losses due to yersiniosis. An assumption was made that hospitalized cases would miss approximately twice as many days of paid work as cases seeking medical assistance, but not hospitalized. The same approach was applied to estimate caregiver working time lost due to yersiniosis.

AGI due to STEC infection can be classified as resulting in bloody or non-bloody diarrhea. These disease states have previously been modeled with median durations of 5 and 3 days respectively (Cressey and Lake, 2007; Havelaar *et al.*, 2004). The majority of bloody diarrhea cases are likely to consult a medical professional, while the majority of non-bloody diarrhea cases are unlikely to consult a medical professional. For the purpose of the current cost of illness study, days of work missed by bloody diarrhea cases will be calculated as equivalent to a general AGI case in New Zealand who consults a medical professional (mean 4.3 days). Days of work missed by non-bloody diarrhoea cases was calculated as equivalent to a general AGI case in New Zealand who does not consult a medical professional (mean 1.5 days). Days of work missed by caregivers was similarly taken from the New Zealand AGI study.

6.2.2 Length of time away from work – listeriosis

It was assumed that cases surviving perinatal listeriosis would not suffer any disease-related absences from work, once working age was achieved. This assumption is supported by a New Zealand study that followed 9 of 13 perinatal listeriosis survivors and found that they were normally developed by 4 to 30 months of age (Lennon *et al.*, 1984).

No New Zealand specific information was found on time spent away from work for adult listeriosis cases. The majority of these cases will be outside working age range. Abelson *et al*. (2006) concluded that surviving listeriosis cases would be off work for at least one month and possibly up to six months. Based on these figures the current study modeled time off work for surviving work age listeriosis cases as a Pert distribution with minimum 20 days, most likely 30 days and maximum 120 days. The age of acquired listeriosis cases was modeled using a non-parametric distribution, based on the recorded ages of cases discharged from hospitals in New Zealand.

6.2.3 Length of time away from work – reactive arthritis

Mangen *et al*. (2004) assumed that ReA cases not attending a GP would continue their lives largely without interruption and would require no time away from work, while cases attending a GP, but not hospitalized, would only require time away from work to attend the GP (uniform distribution 0 to 0.25 days). For hospitalized cases an average time away from work of 26 days was used for calculating productivity losses.

The current study adopted the assumptions made by Mangen *et al*. (2004). No lost work time for a caregiver was included in the current study.

6.2.4 Length of time away from work – Guillain-Barré Syndrome

No New Zealand specific information was found on the amount of work missed by people suffering GBS. It has been assumed that all GBS cases will be hospitalized at some stage and the period of hospitalization provides a lower limit to the period of work missed for those in employment.

Abelson *et al*. (2006) in an Australian study to estimate the costs of foodborne illness used a mean duration of illness of 90 days to calculate costs. Mangen *et al.* (2004) applied four different scenarios for sickness leave:

- For mildly affected cases, sickness leave was uniformly distributed between the time of hospitalization and the ‘friction period’ (the average time to replace a worker) of 123 days. As previously discussed, the friction method of estimating productivity losses due to absence from the work force is not currently believed to be the best model for New Zealand. However, the approach of Mangen *et al*. (2004) and Abelson *et al*. (2006) will give similar results and the approach of Mangen *et al*. (2004) has been adopted for the current study. Further time off work for physiotherapist or neurologist visits was also included, with the duration of sick leave for each visit being uniformly distributed between 0 and 0.25 days.
- For severely affected cases where full recovery is achieved and the period of sickness leave is modeled as an exponential function with mean 161 days.

- For severely affected cases where full recovery is not achieved, but a good outcome (F-score 0, 1 or 2) is achieved and the sickness period is modeled as an exponential function with mean of 317 days.
- For severely affected cases where full recovery is not achieved and the case becomes a permanent invalid. In these instances, each case is simulated to determine the age at onset of disease and the number and value of productive years lost.

The more detailed approach of Mangen *et al*. (2004) was adopted for the current study.

6.2.5 Length of time away from work – inflammatory bowel disease

No New Zealand-specific data on work absence due to IBD was found. Mangen *et al.* (2004) concluded that the proportion of IBD cases experiencing extending periods of time away from work, other than for doctor's visits and treatment incidents, was very close to the proportion hospitalized. These proportions were taken from the study of Blomqvist and Ekbom (1997) as 39/150 Crohn's disease patients and 38/300 ulcerative colitis patients (Blomqvist and Ekbom, 1997). The New Zealand study of Gearry *et al.* (2006) was used to estimate the proportion of IBD cases that would have Crohn's disease and ulcerative colitis. Periods of sickness leave of 44 days for Crohn's disease and 58 days for ulcerative colitis were used by Mangen *et al*. (2004) and these have been adopted for the current study. While other diseases come under the heading of IBD, no information on work absence due to these diseases was found in the literature.

The age distribution for IBD cases (Gearry *et al*., 2006) was used to calculate the proportion of hospitalized cases in working age range (15-65 years).

6.2.6 Length of time away from work – haemolytic uraemic syndrome

For HUS cases of working age, the time away from work was taken to be the duration of clinical HUS. This was simulated individually for each case, using the approach of Havelaar *et al*. (2004), who modeled the duration of clinical HUS as a uniform distribution between 14 and 28 days.

6.2.7 Length of time away from work - end stage renal disease

ESRD was not included in the other cost of foodborne illness exercises consulted. A conservative approach has been adopted for the current exercise and it has been assumed that ESRD cases will be unable to work for the duration of their lives.

6.2.8 Productivity losses – death

Given the near full employment situation currently prevailing in New Zealand, productivity losses associated with fatal cases were valued using the Human Capital Method. This method is based on the concept that there will be an ongoing cost associated with the withdrawal of a person from the work force. This includes cases of perinatal listeriosis.

For the purpose of the current study it has been assumed that fatal cases would have been productive up to age 65 or a maximum of 50 years for fatalities at ages less than 15 years of age. Ages of fatal cases were simulated from distributions fitted to observed fatality ages for each disease. Due to the relatively few data available on age at death for various microbial

diseases, the age was modeled using uniform or triangular distributions. Productivity losses were calculated as the cumulative lost income based on the national average income ($667 per week), discounted at 3.5% per year (Grocott *et al.*, 2007). This discount rate is similar to that used by Kemmeren *et al.*, (2006) for the Dutch study (4.0%). A recent report by the New Zealand National Occupational Health and Safety Advisory Committee used a discount rate of 3.8% in estimating human capital costs (see: http://www.nohsac.govt.nz/techreport4/index.php?section=sec4:s2:p059:).

7 MODEL

As a number of the inputs used in this analysis were distributions derived from ranges of values or estimates, it was decided to generate COI outputs using a Monte Carlo simulation modelling approach. As for the DALY estimates, input values or distributions were entered into a model constructed using @RISK software (Palisade Corporation). A spreadsheet page was constructed for each individual illness.

The variable inputs used to derive estimates of foodborne disease incidence have been described previously (Cressey and Lake, 2007). Most of the cost inputs used in the current study were deterministic (e.g. the cost of a GP consultation). Some input costs and durations were represented stochastically and, in these cases, the approach has been described in sections 4-6 of this report.

Simulations were run for 10,000 iterations.

8 RESULTS: COST OF ILLNESS ESTIMATES

Results of the simulation of costs of illness associated with six potentially foodborne microbial diseases and their sequelae in New Zealand are summarised in Table 8. While all outputs are statistical distributions, for the sake of concision, outputs are represented here by the mean and the 95% confidence interval (the 2.5th and 97.5th percentiles).

Table 8: Summary results – Cost of Illness (COI) for major foodborne infectious intestinal diseases in New Zealand

Disease State	Incidence (Cases per year) Mean (95%CI)	Cost Components ($000,000) Mean (95% CI)			COI ($000,000) Mean (95% CI)	
		DHC	DNHC	INHC	Total	Foodborne
Campylobacteriosis						
GE, total	123,000 (86,000-177,000)					
GBS, total	28 (24-32)					
ReA, total	3,200 (2,300-4,200)					
IBD, total	49 (36-63)					
Total		**7.8 (7.1-8.9)**	**0.61 (0.53-0.73)**	**124 (92-163)**	**134 (101-172)**	**74 (51-102)**
Salmonellosis						
GE, total	16,800 (5,200-32,000)					
ReA, total	365 (160-630)					
IBD, total	4 (1-8)					
Total		**0.78 (0.66-0.95)**	**0.06 (0.04-0.09)**	**3.8 (2.5-5.7)**	**4.8 (3.4-6.8)**	**2.8 (1.9-4.0)**
Listeriosis (Perinatal)						
Total	6 (5-10)					
Total		**0.02 (0.0-0.06)**	**<0.001**	**2.7 (0.8-5.8)**	**2.7 (0.8-5.8)**	**2.3 (0.7-4.8)**
Listeriosis (Acquired)						
Total	18 (15-27)					
Total		**0.2 (0.1-0.3)**	**<0.001**	**0.1 (0.02-0.4)**	**0.3 (0.1-0.6)**	**0.2 (0.1-0.5)**
STEC infection						
GE, total	340 (170-760)					
HUS, total	10 (3-19)					
ESRD	1 (0-4)					
Total		**2.0 (0.1-7.2)**	**0.1 (0.002-0.6)**	**1.8 (0.04-5.0)**	**4.0 (1.5-12.0)**	**1.6 (0.06-4.8)**

Disease State	Incidence (Cases per year) Mean (95%CI)	Cost Components ($000,000) Mean (95% CI)			COI ($000,000) Mean (95% CI)	
		DHC	DNHC	INHC	Total	Foodborne
Yersiniosis						
GE, total	7,900 (5,500-10,900)					
ReA, total	80 (45-120)					
Total		**0.22 (0.2-0.25)**	**0.02 (0.02-0.03)**	**2.2 (1.5-3.2)**	**2.4 (1.7-3.5)**	**1.4 (0.9-2.0)**
Norovirus infection						
GE, total	108,000 (19,000-450,000)					
Total		**1.2 (0.3-4.3)**	**0.1 (0.02-0.5)**	**6.3 (1.5-23)**	**7.6 (1.9-27)**	**3.0 (0.7-11)**

GE = gastroenteritis
ReA = Reactive Arthritis
HUS = Haemolytic Uraemic Syndrome
DHC = Direct health-care costs
INHC = Indirect non-health-care costs
GBS = Guillain-Barré Syndrome
IBD = Inflammatory Bowel Disease
ESRD = End Stage Renal Disease
DNHC = Direct non-health-care costs
95% CI = 95th percentile confidence interval

There is significant uncertainty associated with cost estimates for all microbial pathogens included in this study. However, this uncertainty is principally driven by uncertainty in the number of cases of disease, rather than the uncertainty in the unit costs. In particular, there is a high level of uncertainty around cost estimates for disease associated with STEC and norovirus infection. For STEC infection this is largely due to the uncertainty around the number of cases that will develop HUS and subsequently develop ESRD, as each case of ESRD incurs significant costs over an extended period of time. For norovirus infection, the costs associated with each case are relatively modest, but there is a high level of uncertainty about the number of cases.

8.1 Sensitivity Analysis

The model was run using values of 0.0, 3.5, 5.0 and 10% for the discount rate, in line with PHARMAC guidelines (Grocott *et al.*, 2007). Results are reported in Table 9.

Table 9: Sensitivity analysis for the cost of foodborne illness in New Zealand to the rate of discounting

Disease	Cost component	Base Case (Discount rate = 3.5%)	Discount rate = 0%	Discount rate = 5%	Discount rate = 10%
Campylobacteriosis	DHC	7.8 (7.1-8.9)	8.9 (8.0-10.2)	7.5 (6.9-8.6)	7.1 (6.6-7.9)
	DNHC	0.6 (0.5-0.7)	0.6 (0.5-0.7)	0.6 (0.5-0.7)	0.6 (0.5-0.7)
	INHC	124 (92-163)	127 (94-166)	123 (91-162)	122 (94-154)
	Total	134 (101-172)	137 (104-175)	133 (99-171)	132 (99-171)
	Total (Foodborne)	74 (51-102)	77 (52-105)	74 (50-101)	73 (53-95)
Salmonellosis	DHC	0.8 (0.7-0.9)	0.9 (0.7-1.2)	0.8 (0.7-0.9)	0.7 (0.7-0.8)
	DNHC	0.06 (0.04-0.09)	0.06 (0.04-0.09)	0.06 (0.04-0.09)	0.06 (0.04-0.09)
	INHC	3.8 (2.5-5.7)	4.4 (2.5-7.7)	3.7 (2.5-5.3)	3.5 (2.6-4.5)
	Total	4.8 (3.4-6.8)	5.3 (3.4-8.7)	4.7 (3.4-6.4)	4.4 (3.4-5.7)

Disease	Cost component	Base Case (Discount rate = 3.5%)	Discount rate = 0%	Discount rate = 5%	Discount rate = 10%
	Total (Foodborne)	2.8 (1.0-4.0)	3.2 (1.9-5.3)	2.7 (1.9-3.8)	2.5 (1.9-3.2)
Listeriosis (Perinatal)	DHC	0.02 (0.0-0.06)	0.02 (0-0.06)	0.02 (0-0.06)	0.02 (0-0.06)
	DNHC	<0.001	<0.001	<0.001	<0.001
	INHC	2.7 (0.8-5.8)	5.7 (1.7-12)	2.1 (0.6-4.5)	1.1 (0.3-2.4)
	Total	2.7 (0.8-5.8)	5.8 (1.7-12)	2.1 (0.6-4.5)	1.2 (0.4-2.4)
	Total (Foodborne)	2.3 (0.7-4.8)	4.9 (1.4-9.9)	1.8 (0.5-3.7)	1.0 (0.3-2.0)
Listeriosis (Acquired)	DHC	0.2 (0.1-0.3)	0.2 (0.1-0.3)	0.2 (0.1-0.3)	0.2 (0.1-0.3)
	DNHC	<0.001	<0.001	<0.001	<0.001
	INHC	0.1 (0.02-0.4)	0.1 (0.02-0.5)	0.1 (0.02-0.4)	0.1 (0.02-0.4)
	Total	0.3 (0.1-0.6)	0.3 (0.1-0.7)	0.3 (0.1-0.6)	0.3 (0.1-0.6)
	Total (Foodborne)	0.2 (0.1-0.5)	0.3 (0.1-0.6)	0.2 (0.1-0.5)	0.2 (0.1-0.5)
STEC infection	DHC	2.0 (0.1-7.2)	3.9 (0.1-15)	1.6 (0.1-5.9)	1.1 (0.1-3.4)
	DNHC	0.1 (0.002-0.6)	0.1 (0.002-0.6)	0.1 (0.002-0.6)	0.1 (0.002-0.6)
	INHC	1.8 (0.04-5.0)	3.6 (0.04-10)	1.5 (0.04-4.3)	0.8 (0.04-2.4)
	Total	4.0 (1.5-12.0)	7.6 (0.2-24)	3.2 (0.1-9.6)	2.0 (0.1-5.8)
	Total (Foodborne)	1.6 (0.06-4.8)	3.0 (0.06-9.6)	1.3 (0.6-3.8)	0.8 (0.06-2.3)
Yersiniosis	DHC	0.22 (0.20-0.25)	0.22 (0.20-0.25)	0.22 (0.20-0.25)	0.22 (0.20-0.25)
	DNHC	0.02 (0.02-0.03)	0.02 (0.02-0.03)	0.02 (0.02-0.03)	0.02 (0.02-0.03)
	INHC	2.2 (1.5-3.2)	2.3 (1.5-4.0)	2.2 (1.5-3.1)	2.1 (1.5-2.9)
	Total	2.4 (1.7-3.5)	2.5 (1.8-4.3)	2.4 (1.8-3.4)	2.4 (1.8-3.2)
	Total (Foodborne)	1.4 (0.9-2.0)	1.4 (0.9-2.5)	1.4 (0.9-2.0)	1.3 (0.9-1.9)
Norovirus infection	DHC	1.2 (0.3-4.4)	1.2 (0.3-4.4)	1.2 (0.3-4.4)	1.2 (0.3-4.4)
	DNHC	0.1 (0.02-0.5)	0.1 (0.02-0.5)	0.1 (0.02-0.5)	0.1 (0.02-0.5)
	INHC	6.3 (1.5-23)	6.4 (1.5-23)	6.2 (1.5-23)	6.2 (1.5-23)
	Total	7.6 (1.9-27)	7.7 (1.9-28)	7.5 (1.9-27)	7.5 (1.8-28)
	Total (Foodborne)	3.0 (0.7-11)	3.0 (0.7-11)	2.9 (0.7-11)	2.9 (0.7-11)

DHC = Direct health-care costs DNHC = Direct non-health-care costs INHC = Indirect non-health-care costs
95% CI = 95th percentile confidence interval

Direct health care and non-health care costs are generally insensitive to the discount rate, as most costs are incurred in the first year. A significant exception to this is for STEC infection, where health care costs associated with ESRD may continue to be incurred for periods as long as 70 years.

Indirect non-health care costs are generally more sensitive to the discount rate. This is largely due to lost productivity associated with fatal cases. The degree of sensitivity depends on the case fatality rate for the particular disease and the age at which fatality occurs. For example, fatal norovirus cases are usually in the age range 70-90 years and, under the methodology used in the current study, these deaths would not result in any loss of productivity. In contrast, STEC-associated fatalities are as likely to be very young as very old and these fatalities would result in the loss of the complete productive lifetime of the individual. For STEC infection (and sequelae) increasing the discount rate from 0 to 10% results in a

decrease in the mean estimated cost of foodborne illness from $3 million to $800,000. Similar sensitivity is seen in the cost estimates for perinatal listeriosis.

For the other diseases included in this study, most of the burden on society will occur in the first year and most fatal cases will be beyond or near the end of their productive working life. For these reasons the estimates of cost for these diseases are less sensitive to the discount rate.

8.2 Cost of Illness per Case

While the total cost of foodborne illness due to particular microbial hazards provides a means of ranking the risks associated with these hazards, this approach will inevitably place more weight on more frequently occurring diseases. Table 10 calculates a 'cost per case' for the microbial hazards included in this study. This is calculated by dividing the total costs of foodborne disease caused by the hazard by the number of cases. For example, for campylobacteriosis the total costs estimated for *Campylobacter* enteritis, GBS, ReA and IBD were divided by the estimated number of *Campylobacter* enteritis cases, as each sequela case has been assumed to have previously been an enteritis case.

Table 10: Cost per cases for foodborne disease in New Zealand

Disease	Estimated incidence, 2005 Mean (95% CI)	Total cost of foodborne illness ($M) Mean (95% CI)*	Cost per case ($) Mean (95% CI)*
Campylobacteriosis	123,000 (86,000-177,000)	74 (51-102)	600 (350-939)
Salmonellosis	16,800 (5,200-32,000)	2.8 (1.9-4.0)	220 (90-550)
Listeriosis (Perinatal)	6 (5-10)	2.3 (0.7-4.8)	380,000 (110,000-690,000)
Listeriosis (Acquired)	18 (15-27)	0.2 (0.1-0.5)	14,000 (7,000-28,000)
STEC infection	340 (170-760)	1.6 (0.06-4.8)	4,400 (190-13,200)
Yersiniosis	7,900 (5,500-10,900)	1.4 (0.9-2.0)	190 (120-300)
Norovirus infection	108,000 (19,000-450,000)	3.0 (0.7-11)	50 (8-220)

95% CI = 95th percentile confidence interval
* Based on a discount rate of 3.5%

The very high cost per case for perinatal listeriosis reflects the high mortality associated with this condition and the high resultant productivity losses (equivalent to an entire working lifetime for fatal cases). For diseases other than listeriosis the cost per case is a reflection of the number and severity of sequelae and the likely severity of the initial gastroenteritis. For example, the low cost per case for norovirus reflects the lack of any identified sequelae and the relatively short-term nature of the gastroenteritis experienced.

While the rank order of the cost per case values in Table 10 is similar to that determined previously for New Zealand by Scott *et al.* (2000), the actual values are substantially different in most cases.

9 DISCUSSION

The total estimated cost to New Zealand society due to foodborne transmission of the diseases in Table 8 is estimated to be approximately $86 million (95% CI 61-115), with approximately 90% of the cost due to lost productivity associated with people temporarily or permanently removed from the work force. Illness due to *Campylobacter* accounts for approximately 90% of the total estimated cost of foodborne illness. These figures are based on actual and estimated disease cases for 2005 and unit cost estimates from the period 2006-2007. The ranking of foodborne microbial hazards on the basis of the cost of resultant illness gives a very similar ranking to that derived from earlier DALY estimates (Cressey and Lake, 2007). This is not surprising, as both methods derive the estimates from the same disease incidence rates.

While methodologies differ quite markedly, these findings are reasonably consistent with former estimates for New Zealand (Scott *et al.*, 2000). The analysis by Scott *et al*. (2000) included a wider range of food poisoning organisms, but a less detailed consideration of sequelae. Their analysis estimated a total cost due to foodborne illness of $55 million, with 87% of the estimate due to lost productivity and 73% of the total cost due to *Campylobacter*.

Abelson *et al*. (2006) estimated the annual cost of foodborne illness in Australia as $A 1,249 million or approximately 18 times the costs determined in the current study (the Australian population is approximately five times the New Zealand population). The Australian study included toxoplasmosis and hepatitis A infection, which were not included in the current study, and considered acute gastroenteritis in general, rather than ascribing it to individual organisms. Abelson *et al*. (2006) based their cost estimates for gastroenteritis on an estimated 5.4 million cases, while the sum of the mean gastroenteritis cases valued in the current study was only 250,000. This is consistent with the findings of the recent New Zealand Acute Gastrointesinal Illness (AGI) Study, that reported that no pathogen was identified in 80% of faecal specimens submitted from cases of AGI (King *et al.*, 2007).

Abelson *et al*. (2006) also included irritable bowel syndrome as a sequela, rather than inflammatory bowel disease. There is still international discussion concerning which of these is more appropriate. End stage renal disease was not included as a sequela. While the Australian study included the same cost elements as in the current study, a wider range of costs consequent to infection were valued:

- Public foodborne illness surveillance and control costs;
- Loss of household productivity and disruption to household activities;
- Lifestyle disruption, including pain and suffering;
- Value of a life (for fatal cases), based on willingness to pay methodology rather than the loss of productivity approach taken in the current study; and
- Business costs in provision of safe food (compliance and disruption costs).

When only aspects of the Australian study that were equivalent to those in the current study were considered, including retaining irritable bowel syndrome as a surrogate for inflammatory bowel disease, the approximate equivalent cost of foodborne illness in Australia is $A 605 million (approximately $NZ 710) or approximately 8.5 times the cost of foodborne illness in New Zealand, for a five times larger population.

Kemmeren *et al*. (2006) used very similar methodology to the current study to determine cost estimates for *Campylobacter, Salmonella* and norovirus related disease for the Netherlands.

When figures are corrected for differences in population and exchange rates, the Dutch estimate for the cost of illness associated with *Campylobacter* is approximately one-sixth of the estimate for New Zealand, *Salmonella* is approximately 1.5 times the estimate for New Zealand and norovirus is four times the estimate for New Zealand. These comparisons will be influenced by the differences in the incidence of these disease between the two countries as well as differences in the cost of healthcare. The Dutch study employed the friction method for determining the productivity losses due to absence from the work force. This approach limits losses to a period of 123 days – the average time taken to replace a member of the workforce and bring the replacement to full productivity. This approach will put a lower value on productivity losses due to premature death or long term absence from the workforce than the human capital approach adopted in the current study.

The sensitivity of cost estimates to the discount rate was assessed. Most of the estimates were relatively insensitive to changes in the discount rate. The exceptions were the costs associated with STEC infection and perinatal listeriosis, which varied considerably with discount rate. This is due to their impact on the young and the long time course of some of the health consequences.

Estimates were made of the costs resulting from each incident case of foodborne microbial disease. As with a previous New Zealand study, the highest cost per case was associated with listeriosis, while norovirus infection had the lowest cost per case.

The current study has a number of limitations, including:

- Uncertainty about the actual numbers of cases of foodborne diseases in New Zealand. Factors used to scale up from notifications to total cases are often large and uncertain.
- Lack of New Zealand specific information about the epidemiology and clinical course of the diseases included in this study. Many of the factors incorporated into the model are 'borrowed' from overseas studies and the relevance to the New Zealand situation is unknown.
- Lack of information on the extent of caregiver absence from work, associated with sequelae following acute gastrointestinal illness.

The current study did not attempt to value losses due to time spent with disease, other than those associated with lost working time. Cost due to surveillance and control activities are also not included.

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APPENDIX 1 PREDOMINANT DIAGNOSIS RELATED GROUP (DRG) CODES ASSOCIATED WITH SELECTED ICD-10 CODES IN NEW ZEALAND HOSPITAL DISCHARGE RECORDS

Condition	ICD-10 Code	DRG Code	Description	Percent of admissions with ICD-10 code with DRG Code
Campylobacter enteritis	A04.5	G67B	Oesophagitis Gastroent & Misc Digestive Systm Disorders Age>9 W/O Cat/Sev CC	71.4
		G67A	Oesophagitis Gastroent & Misc Digestive System Disorders Age>9 W Cat/Sev CC	15.8
		G68B	Gastroenteritis Age <10 W/O CC	7.7
		G44B	Other Colonoscopy W/O Catastrophic or Severe CC	1.6
		G68A	Gastroenteritis Age <10 W CC	0.9
Salmonella enteritis	A02.0	G67B	Oesophagitis Gastroent & Misc Digestive Systm Disorders Age>9 W/O Cat/Sev CC	49.6
		G67A	Oesophagitis Gastroent & Misc Digestive System Disorders Age>9 W Cat/Sev CC	18.2
		G68B	Gastroenteritis Age <10 W/O CC	24.5
		G44B	Other Colonoscopy W/O Catastrophic or Severe CC	1.0
		G68A	Gastroenteritis Age <10 W CC	4.6
		G45A	Other Gastroscopy for Non-Major Digestive Disease	0.8
STEC infection	A04.0-A04.4	G67B	Oesophagitis Gastroent & Misc Digestive Systm Disorders Age>9 W/O Cat/Sev CC	43.3
		G67A	Oesophagitis Gastroent & Misc Digestive System Disorders Age>9 W Cat/Sev CC	12.2
		G68B	Gastroenteritis Age <10 W/O CC	27.8
		G44B	Other Colonoscopy W/O Catastrophic or Severe CC	6.7
		G68A	Gastroenteritis Age <10 W CC	4.4
Yersinia enteritis	A04.6	G67B	Oesophagitis Gastroent & Misc Digestive Systm Disorders Age>9 W/O Cat/Sev CC	37.0

		G67A	Oesophagitis Gastroent & Misc Digestive System Disorders Age>9 W Cat/Sev CC	13.0
		G68B	Gastroenteritis Age <10 W/O CC	29.3
		G44B	Other Colonoscopy W/O Catastrophic or Severe CC	4.3
		G68A	Gastroenteritis Age <10 W CC	8.7
		G07B	Appendicectomy W/O Catastrophic or Severe CC	3.3
		G12B	Other Digestive System O.R. Procedures W/O Catastrophic or Severe CC	2.2
Norovirus gastroenteropathy	A08.1	G67B	Oesophagitis Gastroent & Misc Digestive Systm Disorders Age>9 W/O Cat/Sev CC	51.1
		G67A	Oesophagitis Gastroent & Misc Digestive System Disorders Age>9 W Cat/Sev CC	38.3
		G68B	Gastroenteritis Age <10 W/O CC	8.5
		G68A	Gastroenteritis Age <10 W CC	2.1
Guillain Barré Syndrome	G61.0	B71B	Cranial and Peripheral Nerve Disorders W/O CC	73.6
		B71A	Cranial and Peripheral Nerve Disorders W CC	18.1
		A06Z	Tracheostomy or Ventilation >95 hours	6.4
		B60B	Established Paraplegia/Quadriplegia W or W/O O.R. Procs W/O Catastrophic CC	0.5
Reactive Arthritis	M02.1, M02.3, M02.8, M02.9, M46.9	I70Z	Non-specific Arthropathies	33.3
		I66B	Inflammatory Musculoskeletal Disorders W/O Cat or Sev CC	22.9
		I68B	Non-surgical Spinal Disorders W/O CC	15.1
		I68C	Non-surgical Spinal Disorders Sameday	15.1
		I68A	Non-surgical Spinal Disorders W CC	5.2
Inflammatory Bowel Disease	K50, K51	G64Z	Inflammatory Bowel Disease	42.7
		G44C	Other Colonoscopy Sameday	25.3
		G44B	Other Colonoscopy W/O Catastrophic or Severe CC	10.2

		G02B	Major Small and Large Bowel Procedures W/O Catastrophic CC	5.6
		G44A	Other Colonoscopy W Catastrophic or Severe CC	3.1
Haemolytic Uraemic Syndrome	D59.3	Q61C	Red Blood Cell Disorders W/O Catastrophic or Severe CC	32.2
		L60C	Renal Failure W/O Catastrophic or Severe CC	21.5
		Q02A	Other O.R. Procedure of Blood & Blood Forming Organs W Cat or Sev CC	13.6
		L60B	Renal Failure W Severe CC	12.4
		Q61B	Red Blood Cell Disorders W Severe CC	6.9
		L60A	Renal Failure W Catastrophic CC	4.0
		Q61A	Red Blood Cell Disorders W Catastrophic CC	4.0
End Stage Renal Disease	N18.0	L60C	Renal Failure W/O Catastrophic or Severe CC	38.3
		L60B	Renal Failure W Severe CC	24.7
		L60A	Renal Failure W Catastrophic CC	7.1
		L01A	Kidney transplant w catastrophic or severe cc	6.9
		L02Z	Operative insertion of peritoneal catheter for dialysis	5.7
		L01B	Kidney transplant w/o catastrophic or severe cc	4.8
		A09B	Renal Transplant W/O Pancreas Transplant W/O Catastrophic CC	3.6
		L09C	Other Procedures for Kidney and Urinary Tract Disorders W/O Cat or Sev CC	3.6
Listerial meningitis	A32.1	T64A	Other Infectious and Parasitic Diseases W Catastrophic or Severe CC	50.0
		T64B	Other Infectious and Parasitic Diseases W/O Catastrophic or Severe CC	31.3
		A06Z	Tracheostomy or Ventilation >95 hours	6.3
Listerial septicaemia	A32.7	T64A	Other Infectious and Parasitic Diseases W Catastrophic or Severe CC	82.3
		T64B	Other Infectious and Parasitic Diseases W/O Catastrophic or	17.7

			Severe CC	
Listeria, other	A32.8, A32.9	T64A	Other Infectious and Parasitic Diseases W Catastrophic or Severe CC	58.3
		T64B	Other Infectious and Parasitic Diseases W/O Catastrophic or Severe CC	41.7

APPENDIX 2 ICD CODES FOR REQUEST TO NZHIS

The following codes were the subject of the information requested from NZHIS.

Module	Disease type	Disease	Code	Description
Campylobacter	Direct	Gastroenteritis	A04.5	Campylobacter enteritis
Campylobacter	Indirect	Guillain-Barre Syndrome	G61.0	Guillain-Barre Syndrome (GBS)
Campylobacter	Indirect	Reactive Arthritis	M02.1	Postdysenteric arthropathies
Campylobacter	Indirect	Reactive Arthritis	M02.3	Reiter's disease
Campylobacter	Indirect	Reactive Arthritis	M02.8	Other reactive arthropathies
Campylobacter	Indirect	Reactive Arthritis	M02.9	Reactive arthropathy, unspecified
Campylobacter	Indirect	Reactive Arthritis	M46.9	Inflammatory spondylopathy, unspecified
Campylobacter	Indirect	Inflammatory Bowel Disease	K50	Crohn's disease
Campylobacter	Indirect	Inflammatory Bowel Disease	K51	Ulcerative colitis
Salmonella	Direct	Gastroenteritis	A02	Other salmonella infections
Salmonella	Direct	Gastroenteritis	A02.0	Salmonella enteritis
Salmonella	Direct	Gastroenteritis	A02.1	Salmonella septicaemia
Salmonella	Direct	Gastroenteritis	A02.8	Other specified salmonella infections
Salmonella	Direct	Gastroenteritis	A02.9	Salmonella infection, unspecified
Salmonella	Indirect	Reactive Arthritis		As for Campylobacter
Salmonella	Indirect	Inflammatory Bowel Disease		As for Campylobacter
Listeria	Direct	Listeriosis	A32	Listeriosis (excluding Neonatal (disseminated) listeriosis)
Listeria	Direct	Listeriosis	A32.1	Listerial meningitis and meningoencephalitis
Listeria	Direct	Listeriosis	A32.7	Listerial septicaemia
Listeria	Direct	Listeriosis	A32.8	Other forms of listeriosis
Listeria	Direct	Listeriosis	A32.9	Listeriosis, unspecified
Listeria	Direct	Listeriosis	P37.2	Neonatal (disseminated) listeriosis
STEC	Direct	Gastroenteritis	A04.3	Enterohaemorrhagic Escherichia coli infection
STEC	Direct	Gastroenteritis	A04.0	Enteropathogenic Escherichia coli infection
STEC	Direct	Gastroenteritis	A04.1	Enterotoxigenic Escherichia coli infection
STEC	Direct	Gastroenteritis	A04.2	Enteroinvasive Escherichia coli infection
STEC	Direct	Gastroenteritis	A04.4	Other intestinal Escherichia coli infections
STEC	Indirect	HUS	D59.3	Haemolytic uraemic syndrome
STEC	Indirect	ESRD	N18.0	End stage renal disease
Yersinia	Direct	Gastroenteritis	A04.6	Enteritis due to Yersinia enterocolitica (excluding extraintestinal yersiniosis)
Yersinia	Indirect	Reactive Arthritis		As for Campylobacter
Yersinia	Indirect	Erythema nodosum	L52	Erythema nodosum
Norovirus	Direct	Gastroenteritis	A08.1	Acute gastroenteropathy due to Norwalk agent