The economic cost of foodborne disease in New Zealand

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NEW ZEALAND FOOD SAFETY AUTHORITY

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Contents

List of abbreviations

ACC	Accident Compensation Commission
ALOS	Average length of stay
ANZFA	Australia New Zealand Food Authority
AUD	Australian dollar
CPI	Consumer price index
DALY	Disability-adjusted life year
DRG	Diagnosis related group
ESR	Institute of Environmental Science and Research
ESRD	End stage renal disease
FSANZ	Food Standards Australia and New Zealand
GBS	Guillain–Barré syndrome
GE	Gastroenteritis
GP	General practitioner
HACCP	Hazard analysis critical control points
HUS	Haemolytic-uraemic syndrome
IBD	Inflammatory bowel disease
NZFSA	New Zealand Food Safety Authority
PHARMAC	Pharmaceutical Management Agency
ReA	Reactive arthritis
STEC	Shiga toxin-producing *escherichia coli*
USD	United States dollar
VOSL	Value of a statistical life
VOSLY	Value of a statistical life year
WTP	Willingness to pay
YLD	Years of life lost to disability
YLL	Years of life lost to mortality

Executive summary

This report concerns the economic cost in New Zealand of the following six foodborne diseases:

- campylobacteriosis
- salmonellosis
- norovirus
- yersiniosis
- STEC
- listeriosis

All of them are bacterial infections except norovirus (which is a virus) and all may spread through ingesting contaminated food.

All are characterised by gastroenteritis with diarrhoea and related symptoms. Most are self-treated and may not be recognised by the health system or impose a recognisable burden on the economy. Some, however, may be treated by general practitioners and others may develop complications and require extensive treatment and hospitalisation, including in isolated instances, protracted care extending well beyond the year in which the infection occurred.

There are five main components to the cost of these diseases comprising:

- Costs of regulation and surveillance incurred by the Government
- Costs borne by businesses, including the costs of compliance and the consequential costs of food incidents and disease outbreaks
- Costs of treatment—incurred mainly by the government by way of subsidies towards the cost of GP services, other community care and payments for inpatient hospital care
- Costs associated with loss of output because of worker absenteeism caused by foodborne disease
- Personal and lifestyle costs incurred by households and individuals in connection with private disbursements (where no recourse to government subsidy exists) and pain, suffering and disruption, including the possibility of premature death

Most costs of government regulation and many costs to businesses are fixed costs that cannot easily be allocated to individual diseases, except in a few specific instances. All other costs are variable and specific and are a function of the frequency, type and progression of incident cases of disease.

The method of calculating each category of disease-specific variable cost involves multiplying the relevant central estimate of volume by price—i.e. health services per incident case × unit price in the case of treatment; days lost per incident case × earnings in the case of loss of output; and the number of days of healthy living lost to disability per incident case × cost of disability and death in the case of personal losses, including lifestyle and pain and suffering. Because the personal cost of disability includes costs attributable to loss of earnings by households, to avoid double counting, output losses borne by households are subtracted from total personal losses to yield a residual lifestyle loss.

The table below summarises central estimates for the aggregate cost of foodborne disease in 2009 for each of the five cost categories identified above.

Summary of central estimates of total costs of foodborne diseases, 2009

Type of cost	$ million	
Government outlays	16.40	
Industry costs	12.30	
Subtotal, government & industry costs		*28.70*
Treatment costs	6.19	
Output loss[1]	27.32	
Residual private costs	99.67	
Subtotal, incident case costs		*133.19*
Grand total		***161.90***

[1]Includes losses borne by households

Estimated total costs are $161.9 million. This includes government outlays of $16.4 million, industry costs of $12.3 million and $133.2 million for incident case costs of disease associated with treatment, loss of output and residual lifestyle loss.

Of the estimated $133.2 million attributable to individual diseases, an estimated 38% was attributable to norovirus. As much of the norovirus experience is self-treated, it is relatively inconspicuous to the health system.

Campylobacteriosis is the most costly foodborne disease recognised within the health system, amounting to $36 million or 27% of all disease-specific costs—followed by salmonellosis ($15.4 million, 12%) and listeriosis (15.2 million, 11%)—which, despite its low volume, has a high cost per case, augmented by its potential for serious complications and its high risk of premature death.

STEC accounted for $14.6 million (11%), reflecting the associated risk of its rare but severe complications and premature death. Yersiniosis is a disease of greater frequency than STEC, but its complications are few and with a value of $1.9 million (1%), is the least costly of the six diseases.

Some 98% of incident case costs of disease accrued during 2009. The balance of their costs, because of severe complications in a very small number of cases, will be incurred in years after 2009. The totals in the table above incorporate these ongoing lifetime costs, which are expressed as present values discounted back to 2009 at 3.5% per annum. Because of the small number of cases accruing costs beyond 2009, total incident case costs are not markedly sensitive to the choice of discount rate.

In the case of government outlays, the largest single programme cost is that associated with the administration of a Poultry Risk Management Strategy, amounting to $1 million. The poultry industry spent a further $2.25 million during 2009 on this programme. There is nevertheless evidence to suggest that the Poultry Risk Management Strategy may have been responsible for a reduction in the number of incident cases of campylobacteriosis between 2006 and 2009 of some 53%, with a saving of the order of $40 million.

New Zealand's overall annual cost of foodborne disease per capita appears low compared with Australia or the United States. This may in part reflect a fall in number of cases of GE—and campylobacteriosis in particular, since the mid-2000s as well as relatively low mortality from foodborne disease.

Combined government and industry expenditures represented about 18% of all foodborne disease costs in 2009, but they need to be assessed in relation to the incremental costs they are likely to have averted, rather than in the context of their current share of total costs.

Estimated aggregate incident foodborne case costs of $133.2 million for 2009 (i.e. exclusive of government and industry costs) are higher than the central estimate of Cressey and Lake (2008) for 2005 of $85.3 million, partly because the latter excludes residual lifestyle costs.

Our estimate of costs depends on the accurate enumeration of disease. As only a few cases are formally recognised from notifications to Public Health Units from confirmed laboratory positive stool tests of specimens submitted by GPs, actual cases are estimated by scaling up confirmed notifications. Scaling is also used to arrive at estimates of mortality. Also, as not all cases of disease are foodborne, the attribution of estimated incident cases to foodborne causes is an additional source of uncertainty.

Each disease has recognised pathways for which it is possible to construct a standard template, indicating the likelihood of self-treatment or the need for medical and other care, depending on the complications that could develop and their severity. Pathways of disease and the patterns and frequency of care they attract are also subject to uncertainty—as are their implications for worker absenteeism and personal and lifestyle disruption.

The report contains three main sections that deal with the material in the following way:

- Section 1 outlines the scope of the study and describes evidence on the incidence of foodborne disease and its impact, including examples of disease outbreaks—and the responses they have occasioned, including prevention, product withdrawal, customer compensation, etc.

- Section 2 describes costs in more detail in three main parts. It first describes the regulatory environment for food in New Zealand and its cost to government; second, it describes how the food industry has complied and responded and arrives at an estimate of the associated industry cost; and third, it assembles evidence for values of inputs to model incident case costs for treatment, output losses and loss of household quality of life and in extreme cases, of premature death.

- Section 3 presents the overall results and discusses their sensitivity to the various inputs used to obtain them as well as their reasonableness and their comparison with results of other studies.

1. Introduction

1.1 Scope

This study estimates the economic costs of six foodborne diseases which are identified in Table 1 below. The most familiar symptoms of these diseases are gastroenteritis manifesting as diarrhoea (which may contain blood or mucus), fever, stomach cramps, nausea and vomiting. In a few instances infections may spread beyond the bowel to affect other parts of the body, with complications that may be long term. All diseases except norovirus are bacterial infections and all may spread through ingesting contaminated food products.

New Zealand maintains a national surveillance database of foodborne gastroenteritis and other infectious diseases managed by The Institute of Environmental Science and Research (ESR) on behalf of the Ministry of Health. Table 1 provides an overview of the number of notified cases in 2009 of the six diseases under consideration, derived from ESR's Episurv surveillance system. This includes the proportion of cases that ESR estimates as likely to be related to foodborne causes (e.g. of the 7,176 notified incident cases of campylobacteriosis, 4,126 are estimated to be foodborne).

Data collected by ESR consist of a summation of cases notified to Public Health Units by GPs and of confirmed laboratory positive stool tests from specimens submitted by GPs. However because most cases are either self-treated or treated by a GP without laboratory investigation or confirmation, the actual number of cases is considerably greater than those notified and must be calibrated.

Table 1: Notified and estimated incident cases of foodborne disease in New Zealand, 2009

Enumeration of cases / Disease	Campylo-bacteriosis	Salmon-ellosis	Noro-virus	Yersin-iosis	STEC	List-eriosis
Notified incident cases	7,176	1,129	349	431	143	28
Notified incident cases estimated as foodborne	4,126	685	138	242	57	23
Reported deaths	0	1	0	0	1	4
Multiplier[1]	10	4	1000	19.4	3.7	1
Estimated actual food-related cases[2]	41,262	2,741	138,204	4,699	210	23
Estimated actual deaths[3]	0	4	0	0	4	4

Source: Personal communication ESR; Lim et al (2010)
[1]Multipliers for campylobacteriosis, salmonellosis, norovirus and listeriosis are as advised by NZFSA; implicit multipliers for Yersiniosis (19.4) and STEC (3.7) are from Cressey and Lake (2008)
[2]Value of multiplier × reported incident cases
[3]Value of multiplier × reported deaths

1.2 Enumeration of diseases

Reported foodborne gastroenteritis disease represents the tip of a surveillance pyramid captured by way of passive reporting systems; the base of the pyramid represents the unrecognised cases that must be accounted for by scaling up notified cases. This is done with the aid of multipliers which have been adopted by NZFSA and by ESR. For instance, from Table 1 it will be noted the multiplier for campylobacteriosis is 10, so notified cases (estimated as foodborne) in 2009 (4,126) need to be multiplied by a factor of 10 to arrive at an estimate of actual incident cases in that year (41,262).

Incident foodborne cases in Table 1 are central estimates subject to two sources of considerable error—first because of uncertainty about the extent of the attribution of incident cases to foodborne causes (in the case of norovirus, for instance, a multiplier of 1000, is one indication of the scale of possible error); and second, because of the way in which notified cases are scaled up to arrive estimates of actual cases.

Although norovirus is the most the prolific disease, almost all cases of norovirus fail to be intercepted within the health system. The multiplier of 1,000 is applied to confirmed norovirus notifications to derive estimates of actual incident cases (138,204). Campylobacteriosis and salmonellosis are thus the two most commonly notified, potentially foodborne gastroenteritis diseases in New Zealand.

In 2006 NZFSA established five-year organisational targets, with 2007 as the baseline that consisted of a 50% reduction in foodborne campylobacteriosis, a 30% reduction in foodborne salmonellosis and no increase in foodborne listeriosis (Lim et al 2010).

Norovirus was not included in the target because of the volatility in its notifications as well as its likely high ratio of person-to-person contamination, outside of the influence of NZFSA. Although the reported incidence of listeriosis is low, it is a high priority because of its severity and its association with high mortality, as discussed further below.

1.3 Disease characteristics, impacts and risks

1.3.1 Campylobacteriosis

Campylobacteriosis is the most visible and recognised source of foodborne disease in New Zealand. Even though it accounts for more reported cases than all other gastro-intestinal illness, it also remains much underreported. As will be shown later, although a few cases of campylobacteriosis may have long-term effects, its health impacts are generally less calamitous than uncommon but better reported diseases such as listeriosis that are always serious conditions and treated within the health system.

Since campylobacteriosis became notifiable in New Zealand in 1980, its reported incidence continued to rise steadily. By the mid-2000s New Zealand was recognised as having the highest incident rate of campylobacteriosis of any high-income country, peaking at 15,873 notifications in 2006, or 383.5 per 100,000.

Campylobacter is commonly found in animals and the environment. It can manifest as a foodborne infection from eating undercooked meats, with poultry meat recognised as the major cause of New Zealand's infections. Other sources of foodborne campylobacteriosis may include red meat and unpasteurised milk, but are much less important than poultry in contributing to New Zealand's persistent and recurring epidemic (Sears et al forthcoming).

Because of its prominence as a source of foodborne disease, NZFSA responded in association with the poultry industry in 2006 by implementing a *Campylobacter* in Poultry Risk Management Strategy. This initiative is the current risk management framework and at the time of writing was intended to remain operational until 2011 (NZFSA 2008a). It includes measures such as performance targets to reduce C*ampylobacter* counts on broiler carcasses after primary processing and public education about hygienic handling of poultry.

Specific measures implemented by industry at the factory level include the use acidified sodium chlorite (SANOVA) for carcass dipping treatment[1] as a potential Critical Control Point for chicken processor HACCP plans; additional carcase washing; more intensive laboratory monitoring and testing; and more extensive use of leak-proof packaging at the retail level for poultry meat.

The new factory initiatives marked a change in philosophy underlying the poultry industry's risk management from a perceived over-dependence on biosecurity standards for contract broiler farms, to a model including more intensive factory management of carcass processing, where risks are more controllable.

[1] http://www.ecolab.com/Initiatives/FoodSafety/FST/Images/SanovaPoultryCS2006v2.pdf accessed 30 September, 2010

The NZFSA Poultry Risk Management Strategy appears to have been vindicated since its implementation. Confirmed annual campylobacteriosis notifications declined between 2002–2006 and 2008 from 354 to 162 per 100,000—a fall of 54%. There is epidemiological evidence, moreover, to directly link this decline to NZFSA's new strategy (Sears et al forthcoming). An independent evaluation has favourably acknowledged these in initiatives, although to minimise the risk of cross-contaminating incoming flocks, it also advocated consideration of even stricter (and more costly) practices, such as complete de-stocking of slaughter houses where contamination occurs (Slorach 2008).

1.3.2 Salmonellosis

Salmonella is second only to *Campylobacter* as one of the three most important pathogens in New Zealand. The trend in overall salmonellosis notifications has increased since the mid-1990s, peaking in 2001. Since then the trend has been erratic, with estimated foodborne causes falling between 2008 and 2009 from 16.2 to 13.2 per 100,000 persons (Lim et al 2010). Although no single primary exposure pathway has yet been established in New Zealand, the emphasis in incorporating salmonellosis in NZFSA's five-year organisational target may provide a better understanding of its sources.

Explanations for the spread of salmonellosis are diverse and include outbreaks associated with raw carrots, flour, watermelon and retail food outlets. (Lim et al 2010). For example, in 2005 the Auckland Regional Public Health Service investigated an outbreak of 16 notified cases of *Salmonella* saintpaul (an atypical cause of human salmonellosis) (Neuwelt et al 2006). The trace back investigation implicated the ingestion of raw carrots, possibly washed at farms in non potable water. Because of insufficient statistical power, the study failed to confirm carrots as the source of infection. More generally, however, produce-related food microbiological safety issues in New Zealand are rare events.

The most commonly reported foodborne risk factor for salmonellosis notifications during 2006 was consumption of food from retail premises. For 2009 it was estimated that 36% of the transmission foodborne salmonellosis was via poultry (Lim et al 2010).

In late 2008 and early 2009 the largest foodborne outbreak of salmonellosis consisted of 75 cases involving young children. The outbreak was linked to a distinct strain of *Salmonella* (typhimurium phage type 42) and traced to a batch of flour (possibly because of birds contaminating wheat before grinding at a Christchurch mill). The flour had been packaged under different brand names before distribution to various localities in New Zealand. Raw flour appears to have been the vehicle either as play dough or cake mix ingested before being cooked. Epidemiological investigation of this event led to a widely-advertised precautionary voluntary product withdrawal of four brands of flour at risk with 'best-before' dates between June and July 2009 (NZFSA 2008b).

1.3.3 Norovirus

Although noroviruses are the most common cause of non-bacterial gastroenteritis in New Zealand, most cases are self-limiting, with few notified or treated within health system. The likely incidence of norovirus may appear higher than in Australia where surveys of 'gastroenteritis' are likely to include norovirus and campylobacteriosis (e.g. Abelson et al 2006). Noroviruses become most easily recognisable at a public health level, when they occur as outbreaks and can be characterised by serotyping.

Norovirus infections occur following ingestion of faecally-contaminated food and water. Person-to-person transmission is also possible and can dramatically erupt in closed settings such as cruise ships.

A commonly-reported source of outbreaks of norovirus in New Zealand is contaminated shellfish. It was first traced to the consumption of commercially-farmed Pacific oysters in 1999, when 86 cases were identified of whom 32, on faecal analysis, were confirmed as norovirus (Simmons et al 2001). Subsequently, a series of papers has appeared linking outbreaks of norovirus to the consumption of oysters in 2006, including raw Korean oysters directly affecting 352 persons attending a rugby match at Eden Park in Auckland (Simmons et al 2007), an outbreak linked to Korean oysters in New Plymouth affecting 6 persons (Rohleder and de Jager 2007) and a further outbreak linked to oysters at a sports tournament in Christchurch (NZFSA 2007a).

The Eden Park incident is the largest foodborne outbreak of norovirus gastroenteritis documented in New Zealand. Allowing for secondary infections, Eden Park incident cases could ultimately have been as high as 441 (Simmons et al 2007). The series of norovirus outbreaks in 2006 culminated in NZFSA suspending all further imports of oysters from Korea, pending the promulgation of health standards for imported shellfish.

1.3.4 Yersiniosis

Like norovirus, yersiniosis is mostly self-treated, but less common. There were an estimated 4,699 foodborne cases in New Zealand in 2009. New Zealand's rate of reported yersiniosis (431 in 2009), however, is more than ten times above most comparable countries such as Australia and it is the third most frequently notified type of foodborne disease. Most foodborne yersiniosis is likely to be associated with pork and pork products, although it has also been isolated from dairy products, fruit, vegetables, tofu, pastries and sandwiches (Lake et al 2004).

Outbreaks of yersiniosis are uncommon, although minor geographic clusters may occur (Lake et al 2004). An investigation in Christchurch in 2007 found that six children younger than five had contracted yersiniosis where unheated cocktail sausages, handed over the counter in butcheries may have been implicated[2].

1.3.5 STEC

STEC is a relatively uncommon disease in New Zealand, with an estimated 210 foodborne cases in 2009. Its incidence is comparable with other high-income countries, although higher than for Australia (Gilbert et al 2007). All cases of STEC appear to be sporadic with no widespread outbreaks identified. STEC is of concern because a small number of cases develop complications associated with post-diarrhoeal HUS and the risk of ESRD.

The source of STEC is uncertain although raw milk is considered to be a risk (Gilbert et al 2007); another is red meat, particularly where used in the manufacture of small goods such as salami. There have been no cases of STEC in New Zealand traced to small goods, but in 1995following an outbreak in Adelaide of some 200 cases attributable to fermented mettwurst, one person died and 22 children were hospitalised with HUS (Patton and Patton 1998). Following this incident, NZFSA took steps to implement a mandatory standard for the production of uncooked small goods (NZFSA 2007b). This was especially targeted at smaller producers that may not hitherto have operated with a HACCP system in place.

[2] *New Zealand Herald,* 29 November, 2007
http://www.nzherald.co.nz/food/news/article.cfm?c_id=206&objectid=10479003 accessed 30 September, 2010

1.3.6 Listeriosis

Listeriosis is caused by the pathogen, *Listeria monocytogenes*. It may either occur in an invasive or non-invasive form. In the latter, infection remains confined to the digestive system and manifests as gastroenteritis with mild flu-like symptoms. Little is known about the non-invasive form, as it is not notifiable, except when outbreaks occasionally occur (Gilbert et al 2009).

In its invasive form, for which data are provided in Table 1, infection spreads into the blood or the central nervous system or both, before spreading to the brain. The population most susceptible to invasive listeriosis are the elderly, the immunocompromised, the perinatal (including foetuses and neonates) and pregnant women (who risk abortion). Neonatal infections occur primarily as a result of transmission from mother to foetus.

The main sources of exposure are proliferations of bacteria in refrigerated, ready-to-eat foods, including ham, raw and smoked fish and shellfish. The real risk is from extensive growth of bacteria in cooked, perishable, cured and uncured food rather than its presence. There have been two reported outbreaks of invasive listeriosis in New Zealand—one involving shellfish and another of unknown cause (Gilbert et al 2009).

Whilst the number of invasive listeriosis cases reported every year is very small, it is a serious disease associated with high risks of mortality. Some 28% of all deaths caused by foodborne pathogens relate to invasive listeriosis (Rocourt et al 2000). For these reasons, as remarked above, it was included in NZFSA's 2006 five-year organisational targets with a goal of zero increase. This criterion was reinforced in 2009 (NZFSA 2009a).

In general terms, there is a standard in New Zealand that requires all ready-to-eat foods (with certain exceptions, such as raw fruit, meat and vegetables) to meet a zero tolerance of *Listeria monocytogenes* (NZFSA 2008c).

2. Cost of disease

2.1 Costs to government of regulation and surveillance

Both government and business costs associated with the control and management of foodborne disease are largely a product of the institutional framework developed by NZFSA.

Government regulation of food quality standards is an essential dimension of primary preventive health inherent in whole-of-population initiatives such as immunisation, drinking water treatment and standards for occupational health and safety.

In New Zealand, government supervision of control of the food environment is centralised under a single authority—which contrasts with high levels of devolution in Australia. NZFSA provides policy settings and constitutes the apex of a hierarchical system under the Food Act 1981 and the Animal Products Act 1999. It relies in substantial measure on the cooperation of Public Health Units, Territorial Authorities and other contractors to administer and audit food safety programmes.

There are 12 Public Health Units covering 21 District Boards, distributed throughout New Zealand. These have significant immediate responsibility for local monitoring and enforcement of the regulatory environment prescribed by the Food Hygiene Regulations (1974) under contract to NZFSA. So far as the six foodborne diseases are concerned, NZFSA and the Ministry of Health fund Public Health Units as part of Government's overall investigation and monitoring activities, which include:

- collection of records of confirmed cases from GPs and local laboratories;
- management of the testing of specimens in outbreak situations or in cases where there is a suspected common source, such as a person in a high risk category (e.g. a food handler);
- investigation and surveillance of the circumstance and causes of local outbreaks of foodborne disease—such as those described above in relation to campylobacteriosis, salmonellosis and norovirus—two public health units have specialist food teams;
- transmission of records of notified cases to Episurv—the national notifiable disease surveillance database, managed by ESR;
- provision of food premises inspection services on behalf of some Territorial Authorities—including responsibility for processing Codes of Hygienic Practice to minimize the presence of bacteria in the processing, distribution, and marketing of foods;
- dissemination of consumer food safety promotional material;
- inspection and approval on behalf of NZFSA of food businesses that are registered as manufacturers under Regulation 5(7) of the Food Hygiene Regulations; and
- investigations of possible breaches of Food Safety Programmes approved by NZFSA.

Costs to government associated with these activities performed by Public Health Units amounted to $10 million in 2009 and represent an amalgamation of all regulatory activities for food safety (but excluding food exports, labeling, chemical safety and consumer information). They comprise net incremental costs not capable of being recouped from third parties. Broadly, they divide between programme costs (associated with safety, prevention and risk management) and response costs (associated with monitoring and investigation). They exclude administrative costs such as the cost of approving Risk Management Programmes and Food Safety Programmes—which can be recouped from private businesses. These are discussed in Section 2.2 below.

Table 2: Government costs of regulation and surveillance in 2009, $ million

Cost of work undertaken by Public Health Units	10.0
Development of Regulatory standards, including the activities of ESR	5.4
Poultry Risk Management Strategy	1.0
Total	16.4

Source: NZFSA personal communication

The cost of developing regulatory standards and related controls was $5.4 million. This amount includes the overall national surveillance and epidemiological analysis of notifications of foodborne disease, mentioned above that is undertaken by ESR through its responsibility to the Ministry of Health for maintaining the Episurv database. This facilitates the central coordination of monitoring and evaluating evidence of possible disease outbreaks; it also facilitates administration of remedial action through NZFSA such as food withdrawals and warnings.

ESR publishes regular reports on national notifications and analysis of foodborne diseases. It also conducts case-controlled studies and reports on them, with laboratory investigation of samples from suspected foodborne outbreaks at its public health laboratory, including testing of samples to match for like strains that could be due to common sources of contagion (e.g. Lim et al 2010). In general terms, the work of ESR straddles both programme and response activities.

National food safety programmes—the most important of which is the Poultry Risk Management Strategy (described above) targeted at *Campylobacter*—are developed and coordinated under a special compliance funding budget within NZFSA. The cost to government of the poultry strategy during 2009 was $$950,000 (NZFSA 2009b p 25).

Costs for the various activities of government and its agencies in relation to foodborne disease during 2009 amounted to some $16.4 million (excluding costs that can be recouped from business) and are summarised in Table 2.

2.2 Business implications and costs

Costs incurred by New Zealand businesses associated with foodborne disease may be grouped into three broad categories as described below.

- First, there are incremental costs of compliance with general food hygiene regulations, Food Safety Programmes and Risk Management Programmes specifically associated with meat hygiene in the meat processing industry. Many of such costs, however, may have been incurred voluntarily (even without statutory obligation). These, for example, would include maintaining acceptable standards of cleanliness in the interests of operating a competitive and efficient business or factory floor. Costs of compliance may be regarded therefore as the incremental costs that businesses incur in enabling the public to rely on transparent and established performance standards as an implicit hedge against the risk of foodborne disease. Capital costs may also be incurred. NZFSA reports that two-thirds of recurrent funding to maintain compliance with Food Safety Programmes is achieved through cost recovery (NZFSA 2009b p 24). To the extent that businesses recover compliance costs from consumers in the form of higher prices, they may be able to mitigate their impact on business, but they would still represent an economic cost to society.

- Second, business incurs costs associated with implementing new and specifically-targeted national Risk Management Programmes such as that for campylobacteriosis. These costs may be subdivided into transitional capital costs and ongoing recurrent outlays associated with the incremental costs of labour, materials and utilities.

- Third, there are consequential costs of foodborne incidents or disease outbreaks that may be linked to individual businesses or to groups of businesses associated by locality or food type. These businesses may become identified as a result of an inspection following a foodborne incident or through a trace back investigation following an outbreak, using epidemiological techniques. These costs generally fall into the category of remedial costs and may include the costs of food withdrawal or recall—including advertising, stock retrieval, write off and destruction—and general loss of business. If consumers can switch to alternative, competing sources of supply or to substitute products, this may not represent a significant overall economic loss to society.

2.2.1 Compliance costs

Costs of compliance are difficult to quantify. There is no reliable systematic information collected and there are no benchmarks available that could indicate what the aggregate of these industry costs might be. There is nevertheless qualitative evidence to suggest that some food stakeholders consider compliance costs covering food hygiene regulations, Food Safety Programmes and Risk Management Programmes and their implementation to be "unnecessarily complex" and of "major concern"[3].

There is also a reported "alarming inconsistency across the country due to the differing structures, approaches and levels of competence within different Territorial Authorities" as well as diversity in the "the model used to determine" costs of registration and inspection under the Food Hygiene Regulations 1974 (the compulsory alternative to voluntary registration of a Food Safety Programme—an option that became available in 1996). In 2005, unit costs of registration varied between $25 and $1,880. At the time of writing, a revised regime was undergoing Select Committee scrutiny.

The cost incurred by government in approving Food Safety Programs during 2009 was $250,000[4]. This amount would have been recovered in fees and would have represented a cost to business. Food stakeholders are concerned, nevertheless, not only about costs recovered by government and its agencies, but also about the (undocumented) cost of "developing, implementing and maintaining" compliance itself[5].

Another dimension of business compliance costs are those to do with regulations that are specific to the meat processing industry. These costs are principally incurred by virtue of the Animal Products Act 1999 in order to satisfy meat hygiene requirements in New Zealand's export markets. They follow from Risk Management Programmes associated with HACCP activities, including production line monitoring, sampling and testing to safeguard and assure the entry of New Zealand's meat products into major export markets.

Because compliance with these safety regulations reduces efficiency (Antle 2000), they impose private incremental costs associated with more intensive use of labour as well as the application of material inputs. Standards associated with these regulations apply to meat produced for domestic consumption as well as for export, so a share of their cost needs to be allocated to New Zealand's general food compliance costs—as distinct from the share attributable to export compliance.

Cao and Johnson (2006) construct a regression model based on meat production over the years 1929-84, showing under assumptions about effectiveness and with sensitivities for incremental improvement on base levels of safety, how the application of standards for the Animal Products Act is

[3] Hospitality Association of New Zealand, http://www.hanz.org.nz/index.cfm/Industry_Info___Issues/submissions/food/domestic_food_review_submission_20_02_06.html; accessed 30 September, 2010
[4] As advised by NZFSA.
[5] Hospitality Association of New Zealand, *loc cit.*

likely to contribute to the meat industry's total costs. Assuming that base levels of safety are 90%[6], incremental variable costs are likely to be of the order of $44 million at 2009 values[7]; and further assuming that the proportion of this amount allocable to domestic food safety is equivalent to the 15% of meat production consumed domestically (Davidson and Williams 2008), a provision for the local variable cost of meat hygiene compliance in 2009 could be about $6.6 million (subject to the assumptions of the Cao and Johnson model). This excludes incremental deprecation associated with the additional capital requirement for meat hygiene.

2.2.2 Programme costs

As regards the specifically-targeted national risk management programme for campylobacteriosis, the Poultry Industry Association of New Zealand (PIANZ) reports capital costs of $1.76 million incurred thus far into the programme, which would include new equipment, processes and procedures; estimated industry recurrent costs during 2009/10 are reported to be $2.25 million. This includes incremental staff costs of $435,000, review costs of $50,000, laboratory costs of $169,000 and IT costs of $16,000, but excludes depreciation and interest charges[8].

It is unclear whether these costs have been passed on to consumers of poultry. Although the cost of poultry is reported to be higher in New Zealand than in Australia (where campylobacteriosis is of lesser perceived consequence), any cost effect of the programme is confounded by New Zealand’s relatively high cost of feedstock, in turn aggravated by Australia’s drought conditions of the mid-2000s. For biosecurity reasons New Zealand does not import poultry, hence price competition from competing sources of poultry cannot have affected demand for the local product. Although consumption of poultry has fallen since 2005/06, the share of poultry in all meats eaten in NZ has remained constant at about 35% and remains the largest source of meat consumed in New Zealand[9]. PIANZ claims that the poultry risk management programme has reduced its operating margins[10]. If this is the case, it may reduce future investment in the industry.

2.2.3 Specific incident costs

The third category of costs to industry is associated with specific outbreaks of foodborne disease and are typified by the experiences (as related above) caused by contaminated raw flour ingested by children in 2008/09; by locally-farmed, contaminated Pacific oysters in 1999; and by imported Korean oysters catered at an Eden Park rugby match in 2006 (as respectively described above in relation to salmonellosis and norovirus). The business cost implications of contaminated oysters and raw flour, however, were quite different.

2.2.3.1 Contaminated shellfish

In the case of oysters, health authority warnings caused a decline in the demand for shellfish which in the case of the 1999 event had adverse business consequences for local growers of Pacific oysters. This represented an immediate setback for aquaculture, for New Zealand’s fledging export industry in seafood and for opportunities to rejuvenate regional New Zealand. There were parallels with the reported adverse impact of apparent contamination of oysters in Wallis Lake, NSW in 1997 (Abelson et al 2006).

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[6] i.e. 90% of outcomes are negative when product is tested for microbial contamination
[7] @ 5.8 cents/kg = $37 m in 2002 (Cao and Johnson 2009, footnote 4)—CPI-indexed to 2009 values = $44 m
[8] Private communication with the Poultry Industry Association of New Zealand, 10 September, 2010
[9] *Ibid*
[10] *Ibid*

After the 2006 oyster event at Eden Park, imports of Korean oysters were suspended immediately and the caterer concerned removed all oysters from their menu for six months. This was reported to cost the business $40,000. In addition, the caterer offered undisclosed financial compensation to the 352 rugby patrons directly infected[11]. As described above, there have also been outbreaks implicating Korean oysters subsequent to the Eden Park outbreak. Although much of the Eden Park caterer's financial burden may have been covered by insurance (which simply transferred the cost elsewhere), the flow-on business costs to others in the oyster industry would have been considerably higher than the Eden Park incident itself. It created a risk of generally reigniting adverse publicity about the safety of all oysters[12], including those grown in New Zealand, with possibly significant, but indeterminate detrimental local economic consequences, since consumers may often be unable to differentiate between the source of oysters[13].

Following the 1997 incident in Wallis Lakes, NSW, Abelson et al (2006) reported that oyster producers probably incurred business losses of AUD0.5 million in that year and equivalent losses in the years immediately thereafter. Net economic loss would have been smaller if customers of Wallis Lakes had switched to other sources of supply. As discussed below, theses costs are likely to have been less in New Zealand.

2.2.3.2 Contaminated flour

Four retail brands of flour were implicated in the voluntary withdrawal associated with *Salmonella* originating from a Christchurch flour mill. Three brands belonged to a vertically-integrated agrifood business operating the mill and the other to a grocery chain. Two separate parallel withdrawals and consequent remedial actions at the mill were hence required. The businesses concerned were contacted by the Consultant to ascertain what costs the withdrawals entailed, but no information was available. Most likely the following activities and issues would have been relevant to an accounting of this cost:

- temporary closure of the flour mill, removal and disposal contaminated stock, dry cleaning all internal surfaces of silos, bins, bunkers and grinding rolls with surface testing to ensure that all traces of microbiological contamination had been removed; recommissioning;
- loss of milling business arising from decontamination down time;
- withdrawal and disposal of flour in retail outlets throughout New Zealand;
- cash refunds to consumers and stock write offs;
- advertising and publicity;
- additional administration work;
- legal services; and
- possible compensation to consumers who contracted salmonellosis.

Because of the scale and logistics of withdrawing a bulk commodity such as flour, the costs were probably considerable—possibly of the order of $1 million (including the cost decontaminating the mill) and certainly in excess of the AUD200,000 which has been cited as an illustrative of the order of magnitude of mid-1990s recall unit costs (ANZFA, 1998). Abelson et al (2006) estimated the unit cost of withdrawals for the years 1998-2003 at AUD250,000. It is likely, however, the cost of the flour withdrawal may not be representative of other New Zealand withdrawal costs.

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[11] *National Business Review*, 16 July, 2006; http://m.nbr.co.nz/article/eden-park-outbreak-costs-oyster-farmer, accessed 30 September, 2010.

[12] Seafood Industry Council "New Zealand oysters safe, says industry" *Press Release*, 30 June 2006, http://www.seafoodindustry.co.nz/n338,44.html, accessed 30 September, 2010.

[13] Errol Kiong "Oysters are delicious, and these haven't flown the Pacific" *New Zealand Herald*, 15 July, 2006 http://www.nzherald.co.nz/lifestyle/news/article.cfm?c_id=6&objectid=10391418, accessed 30 September, 2010.

2.2.4 Synthesis of business costs

Apart from poultry for which there is a special programme, the New Zealand food industries representing the most identifiable source of foodborne disease appear to be shellfish and most significantly, oysters. Based on the facts available, an approximate estimate of the business cost of the Eden Park incident could be as follows:

- Loss of business reported at $40,000 (disruption, shifting to other sources of supply, etc)
- Provision for compensation offered to 352 directly infected patrons at say, $75 a head could have amounted to $26,400
- Provision for adverse externalities affecting the New Zealand oyster industry (net of any compensating shift to other food) in the year of the incident, say $100,000 (less than the late 1990s estimate of AUD0.5 million for Australia mentioned above, which included other fishing and tourist accommodation losses)

Drawing on the Eden Park incident as an indicator for a unit costing of other foodborne outbreak incidents, and adding a provision of say, $30,000 remedial costs (which were not relevant in the Eden Park incident because the oysters were imported), the 2009 cost to industry of a typical foodborne outbreak in New Zealand involving a withdrawal could have been in the region of $200,000[14]. This would probably be lower than any contemporary estimate for Australia (where labour costs are higher) and would exclude outlier events such as the flour withdrawal associated with the salmonellosis outbreak.

The compliance group of NZFSA maintains a register of food product withdrawals. There are records of 29 food withdrawals for diverse reasons during 2009, including chemical contamination, incorrect labelling, allergens and microbiological contamination. Table 3 provides summary information on the 11 food withdrawals due to microbiological contamination for the six diseases covered by this study—but not including the 2008/09 flour withdrawal. At an estimated $200,000 per incident, the aggregate cost of the 11 withdrawals identified in Table 3 could have been in the order of $2.2 million.

Table 3: Food withdrawals in New Zealand during 2009 due to microbiological contamination

Date	Type of food	Pathogen
January	Ice cream	*L. monocytogenes*
February	Chocolate caramel cluster bars	*Salmonella typhimurium*
February	Ham	*L. monocytogenes*
March	Dandelion root	*E. coli 0157:H7* (STEC)
April	Ice cream	*L. monocytogenes*
June	Baby peppers	*L. monocytogenes*
June	Basil	*L. monocytogenes*
August	Oysters	Norovirus
September	Saveloys	*L. monocytogenes*
September	Saveloys	*L. monocytogenes*
October	Ice cream	*Enterbacter* (STEC) (unconfirmed)

Source: NZFSA compliance group, personal communication

It may thus be possible to summarise indicative estimates for overall business costs of foodborne disease in New Zealand during 2009 as follows:

- Poultry Risk Management Strategy, recurrent costs, $2.25 million;

[14] As this refers to an estimated outbreak / recall unit cost to industry, it is quite different from the estimated "cost to New Zealand" amounting to between $71,800 and $90,000 of the Eden Park outbreak by Simmons et al (2007). The latter derives from aggregate incident treatment case costs (discussed in sub section 2.3.4 of this report).

- flour recall cost, $1.0 million;
- other withdrawal / outbreak costs (Table 3), $2.2 million;
- domestic meat hygiene compliance costs associated with Risk Management Programmes under the Animal Products Act, $6.6 million; and
- costs of Food Safety Programme approval charges to food business by NZFSA, $0.25 million.

This suggests that total business costs could have amounted to $12.3 million in 2009. The estimate excludes incremental costs of business compliance with Food Safety Programmes because (as discussed above) these are impossible to quantify, even on the qualitative evidence available. It also excludes private capital expenditure of $1.76 million on the Poultry Risk Management Strategy and other capital expenditure attributable to domestic meat hygiene, which may be written off over the useful life of the assets concerned.

Total measurable government outlays and industry expenditures on foodborne disease in New Zealand in 2009 could thus have amounted to approximately $28.7 million ($16.4 million for government and $12.3 million for business).

These costs are treated as general costs for 2009 and are not attributed to specific illnesses. For example, although the Poultry Risk Management Strategy targets *Campylobacter*, it is also a response to other risks such as *Salmonella*.

2.3 Treatment costs

The sections that follow move from descriptive settings to consider foodborne disease costs with the aid of economic modelling linked to the volume and characteristics of individual cases. The accuracy of measures of these costs thus depends substantially on the reliability of information about the volume of incident cases of disease and their cause. As indicated above, these estimates are scaled up from notified cases (Table 1).

2.3.1 Definition

Costs directly associated with the individual care and treatment for each of the six foodborne diseases consist of the following elements:

- the cost of general practitioner, specialist and allied health services, medicines, laboratory tests and inpatient hospital care associated with treating all incident cases that occurred during 2009; and
- the associated costs of transport in accessing treatment and care.

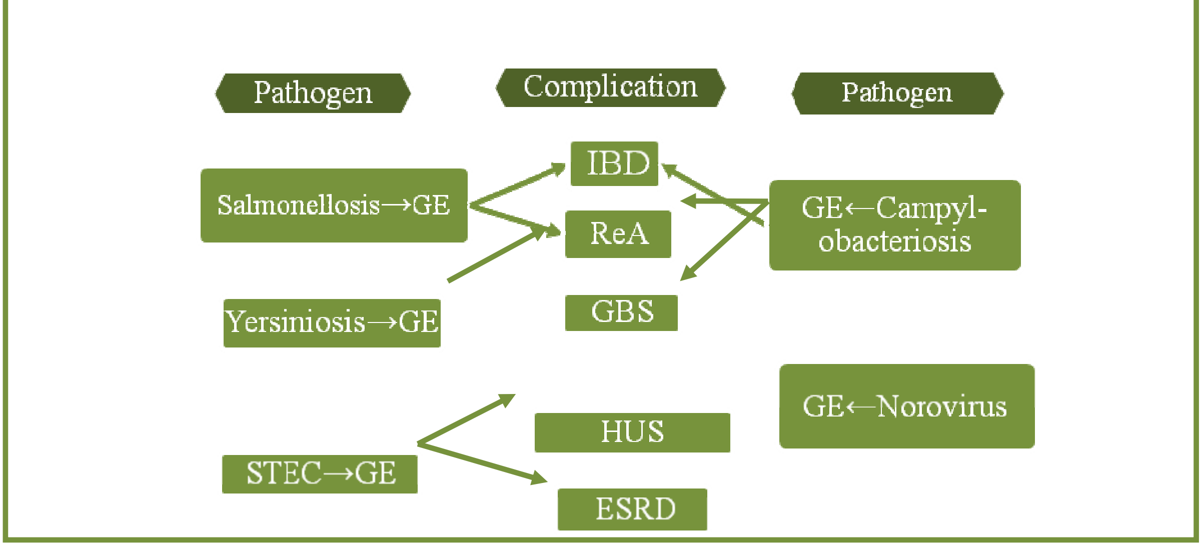
Most treatment costs are borne by government, but consumers may contribute by paying for their transport costs, non-prescription medicines (e.g. Imodium) and any general practitioner or allied health service charges in excess of government payments. They may also pay for, or attract a private health insurance benefit for services such as private hospital care. Almost all hospital care for foodborne diseases, however, is of a type that could be expected to be provided by public hospitals.

The discussion of treatment costs in this section is restricted to costs to government. Patient contributions to treatment and transport fall within the scope of our estimates of household costs based on household willingness to pay to avoid illness, discussed below in sub section 2.5.2. This approach differs from Cressey and Lake (2008), who model treatment costs to include private costs but separately account for travel and Abelson et al (2006) who included private treatment costs (but which were probably relatively low in Australia).

2.3.2 Pathways of disease

Most incident cases of foodborne campylobacteriosis, salmonellosis, norovirus, yersiniosis and STEC will be self-treated and self-limiting or managed within primary care. As mentioned previously, few cases will be enumerated as confirmed laboratory notifications. In most instances, the duration of treatment and recovery from these diseases will be a matter of a few days and they will manifest simply as gastroenteritis without complications.

Figure 1: Schematic of pathways by which complications of foodborne disease can manifest



In the small number of gastroenteritis cases that manifest mild to severe complications such as GBS, IBD and ReA (which will vary according to the type of pathogen) treatment may involve specialist treatment and inpatient hospital care. This can be expected to extend the period of treatment and recovery—occasionally beyond 2009. Norovirus does not manifest complications and is the foodborne disease least likely to be associated with inpatient hospital care.

Pathways describing the way in which complications of foodborne diseases can manifest are represented schematically in Figure 1 above. This shows that all diseases (apart from listeriosis) manifest initially as simple gastroenteritis. Reactive arthritis is a possible complication common to campylobacteriosis, salmonellosis and yersiniosis; IBD may occur both in campylobacteriosis and salmonellosis; and GBS is unique to campylobacteriosis.

Rarely, in the case of STEC, complications may be extreme and manifest as HUS or ESRD, and can be expected to cause lengthy periods of treatment extending well beyond 2009. Listeriosis is invariably a serious disease and always belongs to the highest level of severity. It is the most frequent cause of death amongst foodborne diseases.

From data supplied by ESR, we adopt a methodology for estimating the cost of treatment by characterising each incident case of foodborne disease in New Zealand according to the level of its manifestation and corresponding to severity, as measured by its progression to its highest level of treatment.

Levels of severity (in ascending order) consist of self care, ambulatory care (managed by general practitioners, occasionally with non-inpatient specialist care) and inpatient hospital care—with or without a complication. The most severe cases (treated in hospital) thus move through the full spectrum of treatment types, after in all cases initially seeing a general practitioner.

Classification of the severity of a manifestation of gastroenteritis by the level of its treatment is an alternative method of characterising the transition probabilities associated with the pathways of disease in an outcome tree (e.g. as in Kemmeren et al 2006). ESR supplied estimates of the proportion of incident cases likely to develop complications according to severity (Appendix 1).

2.3.3 Unit prices of treatment costs

Treatment costs are a function of the level of severity or (where applicable) the difficulty. They are the product of the number of treatment services and prescription medicines associated with each 2009 incident case and the unit prices of each of these services. Table 4 provides estimates of average unit prices for non-inpatient services during 2009 paid by government agencies, such as District Health Boards and ACC that purchase services under contract from different groups of health service providers.

Given the high level of devolution in funding and delivering health services in New Zealand, there is no single source of information for the unit prices at which non-inpatient services may be purchased. Neither is there necessarily consistency between prices paid for treatment services to Primary Health Organisations and the like by different District Health Boards or other purchasing agencies in what are essentially discrete, contestable markets. Some specialist and laboratory services, moreover, could have been provided outside the fee for service system by salaried medical specialists employed by District Health Boards. Figures in Table 4 should hence be regarded as indicative averages.

Table 4: Indicative unit prices for government purchases of non-inpatient types of treatment for foodborne disease, 2009, $s (excl. GST)

GP service[1]	28.08
Prescription[2]	23.45
Allied health[3]	38.20
Specialist service[4]	75.00
Laboratory[5]	9.20
Dialysis[6]	613.36

[1]Average subsidy per service paid in remunerating GPs through MoH Sector Services during 2007 ($27.00) (Douglas 2007)—CPI indexed to 2009 values
[2]Average subsidy per prescription listed on the National Pharmaceutical Schedule paid by PHARMAC in 2006/07 ($863.2m ÷ 40m dispensings = $21.58) (Ministry of Health 2006 pp 18-9)—CPI indexed to 2009 values
[3]Average ACC 2007/08 EPN physiotherapy purchase rate ($37.32) (ACC 2009)—CPI indexed to 2009 values
[4]Notional cost to Government of a specialist / specialist hospital outpatient service adopted by Consultant
[5] New Zealand Association of Pathology Practices http://www.nzapp.org.nz/policyIssues.html accessed 30 September, 2010
[6]Cost of dialysis from Christchurch Hospital Nephrology during 2007 ($577.78) (Cressey and Lake 2008 p 16)—CPI indexed to 2009 values

The price of a public hospital separation for each of the diseases is the product of the relevant NZDRG50 cost weight and the value of an average public hospital separation in 2009 (Table 5). The application of the appropriate cost weight captures the cost of all inpatient hospital costs specific to each disease, including accommodation and all inpatient care, medicines, specialist and allied health services, laboratory tests and appliances.

Table 5: Price of public inpatient hospital care for foodborne diseases

Manifestation of disease	NZDRG50	Description of DRG	ALOS	Price, $[2]
GE[1]	G67B	Oesophagitis, gastroenteritis and & miscellaneous digestive system disorders, age >9, without complications	1.9	1,644
	G68B	Gastroenteritis age <10, without complications	1.4	
GBS	B71A	Cranial and peripheral nerve disorders with complications	4.2	4,679
ReA	I66B	Inflammatory musculoskeletal disorders without severe complications	1.9	2,417
IBD	G64Z	Inflammatory bowel disease	2.2	2,590
HUS	L02A	Operative Insertion of Peritoneal Catheter for Dialysis with severe complications	15.6	19,200
ESRD	L60A	Renal failure with catastrophic complications	9.9	10,558
Listeriosis	T01A	Operating room procedures for infectious and parasitic diseases with catastrophic complications	17.5	23,573

[1]Weighted average of G67B and G68B, reflecting the age distribution of notified GE incident cases <10 & >9 (18.5% & 81.5%)
[2] Multi-day inlier cost weight × $4,150.40 (values for calendar 2009, given respectively by the average of 2008/09 and 2009/10 inlier cost weights and hospital separation prices)
Source: Ministry of Health, New Zealand Health Information Service
http://www.nzhis.govt.nz/moh.nsf/b5d4424ece5b89edcc2572130005f838/ee5edcb97900a021cc2572a30005e437?OpenDocument accessed 30 September, 2010

2.3.4 Calculation of treatment costs

The type and frequency of treatment for each disease at their respective levels of severity was obtained from epidemiological evidence supplied to the Consultant by ESR (Appendix 1).

Total treatment costs of foodborne disease during 2009 are thus determined by the following:

- the distribution of the estimated incident cases for each disease given in Table 1 between different manifestations (Figure 1) and by their levels of severity (Appendix 1)
- the cost of the treatment (service frequency × unit price) specific to the range of services for the manifestation of each disease
- the product of sum of the series of treatment costs for each disease and their frequency—which is calculated from frequencies in Appendix 1 and summarised in Table 6.

In the minority of cases where treatment can be expected to extend beyond 2009, the stream of future costs is discounted back to 2009 and expressed as 2009 present values.

Table 6: Central estimates of the treatment cost of incident cases of foodborne disease, 2009 incident cases

Disease	No incident cases	Cost during 2009, $m	Cost after 2009 $m[1,2]	Unit treatment cost per case, $[1,2]	Total lifetime treatment cost, $m[2]
Campylobacteriosis	41,262	2.13	0.04	52.69	2.17
Salmonellosis	2,741	0.19	0.00	71.23	0.20
Norovirus	138,204	1.45	0.00	10.49	1.45
Yersiniosis	4,699	0.12	0.00	24.53	0.12
STEC	210	0.38	1.17	7,202.38	1.51
Listeriosis	23	0.74	0.00	32,313.38	0.74
TOTAL	187,139	5.01	1.18	33.08	6.19

[1]Discounted back to 2009 @ 3.5%
[2] 2009 values

Table 6 above shows that the central estimate of lifetime treatment costs for all 2009 incident cases was $6.2 million. Of this, some 80% is expected to have been incurred for treatment completed during 2009 ($5.0 million). Campylobacteriosis (the principal source of confirmed notifications) is likely to have represented the largest area of treatment cost, amounting to $2.2 million (35% of the total); followed by STEC, $1.5 million (25%); norovirus, $1.5 million (23%); and listeriosis, $0.7 million (12%).

The average treatment cost of the 23 listeriosis cases, about $32,300 per case, exceeded that of all the other diseases. For STEC, some 99% of its treatment costs were attributable to the five cases that progressed to HUS (2% of all STEC cases) and one case that progressed to ESRD. In the case of the latter, the present value of the lifetime treatment cost, involving dialysis and frequent regular hospitalisation, amounted to an estimated $1.3 million, some 88% of which is expected to accrue in years following 2009 (assuming 10-years of survival). Cases of gastroenteritis developing into IBD and in some instances, GBS are also expected to accrue treatment costs beyond 2009.

Table 7: Central estimates of treatment cost by complication, according to level of treatment, 2009 incident cases, $ million

Manifestation / Treatment level	Cost during 2009								Cost after 2009[1,2]			Lifetime cost
	GE	GBS	ReA	IBD	HUS	ESRD	List	Total	GBS	IBD	ESRD	
GP	1.08	0.00	0.01	0.00	0.00	0.00	0.00	1.09	0.00	0.00	0.00	1.09
Prescription	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.53
Allied	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.06
Specialist	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.00	0.07
Laboratory	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07
Dialysis	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.11	0.00	0.00	0.79	0.90
Hospital	1.64	0.41	0.08	0.02	0.22	0.04	0.74	3.15	0.00	0.00	0.30	3.45
TOTAL	3.30	0.47	0.09	0.03	0.22	0.16	0.74	5.02	0.01	0.05	1.09	6.19

[1]Discounted back to 2009 @ 3.5% [2] 2009 values

Table 7 provides an alternative summary of treatment costs according to the level of complication manifest and by types of service. This shows that slightly more than half the cost of treatment was attributable to GE (distributed across five different diseases). Inpatient hospital care accounted also for slightly more than half of all treatment cost, followed by GP services (18%) which was the predominant mode of treatment.

2.4 Costs associated with loss of output

2.4.1 Definition

Loss of output associated with foodborne disease occurs with lost days attributable to each incident case of foodborne disease. Lost days are loss of paid days of employment and losses borne by part-time and self-employed persons (sometimes referred to collectively as human capital loss).
In so far as employers pay workers the value of what they produce, loss of paid output can be measured by the loss of wages. Household losses relate to the loss of income of persons who are self employed or in casual employment as well as the cost of any carer services that households need to purchase. Most lost output will consist of worker and carer paid days lost, borne by employers.

2.4.2 Calculation of costs to output

The loss of each day of output of workers in paid employment is valued at $140.26—the amount of average earnings per day in New Zealand during 2009, including non-wage costs[15]. Output losses

[15] Statistics New Zealand, *Quarterly employment survey,* June 2009, Table 8.01; *Labour cost index (all labour costs),* June 2009 Quarter, Table 1

Table 8: Central estimates of the cost and source of output loss due to foodborne disease, 2009

Disease / Manifestation / Severity		No incident cases, 2009	Source of lost output per case				Cost of lost output[3], $ million
			Paid work		Household days		
			Work days lost[1]	Ratio/ work days lost	Work days lost[1,2]	Ratio/ work days lost	
Campylobacteriosis							
GE	Self care	25,551	2.3	0.5	2.3	0.2	5.77
	Ambulatory	14,122	7.9	0.5	7.9	0.2	10.95
	Inpatient care	511	12.6	0.5	12.6	0.2	0.63
Mild GBS	Inpatient care	2	82.5	0.5	0	0	0.01
Severe GBS	Inpatient care	35	161	0.5	0	0	0.40
ReA	Self care	819	0	0.5	0	0	0.00
	Ambulatory	183	0.25	0.5	0	0	0.00
	Inpatient care	23	26	0.5	0	0	0.04
IBD	Ambulatory	13	2.45	0.5	0	0	0.00
	Inpatient care	3	58	0.5	0	0	0.01
Total campylobacteriosis		41,262					17.82
Salmonellosis							
GE	Self care	1,971	0.49	0.6	1.29	0.2	0.15
	Ambulatory	617	2.06	0.6	2.48	0.2	0.15
	Inpatient care	94	5.73	0.6	3.76	0.2	0.06
ReA	Self care	46	0	0.6	0	0	0.00
	Ambulatory	11	0.25	0.6	0	0	0.00
	Inpatient care	1	26	0.6	0	0	0.00
IBD	Ambulatory	1	2.45	0.6	0	0	0.00
	Inpatient care	0	58	0.6	0	0	0.00
Total salmonellosis		2,741					0.36
Norovirus							
GE	Self care	116,037	0.33	0.5	0.88	0.2	5.55
	Ambulatory	21,848	0.8	0.5	1.33	0.2	2.04
ReA	Inpatient care	319	2.56	0.5	1.68	0.2	0.07
Total norovirus		138,204					7.66
Yersiniosis							
GE	Self care	3,867	1.5	0.6	1.5	0.2	0.65
	Ambulatory	741	4.36	0.6	4.36	0.2	0.36
	Inpatient care	45	8.72	0.6	8.72	0.2	0.04
ReA	Self care	37	0	0.6	0	0	0.00
	Ambulatory	8	0.25	0.6	0	0	0.00
	Inpatient care	1	26	0.6	0	0	0.00
Total yersiniosis		4,699					1.06
STEC							
GE	Self care	111	1.5	0.4	1.3	0.2	0.01
	Ambulatory	92	4.3	0.4	2.7	0.2	0.03
	Inpatient care	1	8.6	0.4	5.4	0.2	0.00
HUS	Inpatient care	5	21	0.4	0	0	0.01
ESRD	Inpatient care	1	261	1	0	0	0.31[4]
Total STEC		210					0.35
Listeriosis							
Acquired	Inpatient care	15	30	1	0	0	0.06
Perinatal	Inpatient care	8	0	0	0	0	0.00
Total listeriosis		23					0.06
Grand total		187,139					27.32

[1]Cressey and Lake (2008) pp 25-9 (as advised by NZFSA)
[2]Data for household days lost due to manifestations other than GE are not available and hence (following Cressey and Lake, 2008) are excluded from the analysis [3]@ $140.26 per day
[4]Includes cost of lost future output attributable to PV @ 3.5% of lifetime paid work days lost in years after 2009 of $0.3m

borne by employers, following Cressey and Lake (2008) on the advice of NZFSA (as shown in Table 8), will thus be the product of:

- estimated incident cases of each disease;
- the duration of worker and carer paid days lost per incident case (Table 8)—specific to its manifestation and level of severity (Appendix 1);
- average daily earnings; and
- the proportion of incident cases for each disease that occurs in the working age population—for example 50% in the case of campylobacteriosis since about half the incident cases of campylobacteriosis in 2009 occurred in persons over 19; 60%, for salmonellosis, and so on, as shown for each disease in Lim et al (2010).

Households are assumed to bear 20% of the loss of output following Abelson et al (2006), reflecting that the most output losses are carried by employers.

Household losses analogously will thus be the product of:

- estimated incident cases of each disease;
- the duration of household days lost per incident case (Table 8)—specific to its manifestation and level of severity (Appendix 1); and
- 20% of total days lost (@ $28.05 per day).

The central estimate of the total cost of output losses associated with 2009 incident foodborne disease is $27 million incurred during 2009, including a provision of $0.3 million for the present value of lifetime paid work days lost accrued by a case of ESRD after 2009 (Table 8, note 4). The largest output loss was due to campylobacteriosis (nearly $18 million), more than 90% of which was for cases treated out of hospital. Other significant contributions to output loss included self-treated norovirus ($5.6 million) and norovirus treated out of hospital ($2 million). As discussed elsewhere, our central estimates depend on values for incident cases which are subject to assumptions and must therefore be interpreted with caution.

2.5 Household costs

2.5.1 Definition

A WTP approach to valuing losses is generally thought to be a more complete statement of costs because it includes a willingness to pay to avoid the loss of earnings described in the previous section as well as the private costs of household disruption—for which no evidence was available for purposes of the loss of output calibration in the previous sub section. WTP also includes an accounting for other private costs such as payments for travel and private payments for treatment (exceeding the level of public subsidy discussed in sub section 2.3.3); it also places a value on the welfare gain in avoiding any risk of pain and suffering (including in self-care situations) as well as in avoiding the risk of premature death.

A general expectation is that a valuation using WTP criteria will exceed that based on loss of output. The amount of the ‘excess’ WTP valuation may be considered as a residual loss attributable to lifestyle, miscellaneous household payments and general household dislocation associated with an episode of illness. The more severe an illness, the greater the likely residual burden of household disruption.

If a loss of output valuation of the cost of foodborne disease is used in conjunction with a WTP valuation, to avoid double counting, the loss of earnings in paid employment should be subtracted from the WTP valuation. This will generally yield a residual lifestyle and pain and suffering cost (Abelson et al 2006; Abelson 2010).

2.5.2 Valuing willingness to pay to avoid disease

It is possible to derive a money metric for private WTP to avoid foodborne disease from the value which New Zealanders assign to the value of a life or a healthy life day. This measures their willingness to pay to reduce the statistical risk of death. Examples of how it could be estimated include a willingness (averaged across all New Zealanders) to trade increased personal risk for monetary reward (such as working in a dangerous occupation that remunerates well) or to incur given safety costs to reduce a known risk of death—from which in each case would follow an implicit valuation of life—referred to as the value of a statistical life (VOSL) (Schelling 1968).

From work on WTP for road safety prevention, the Ministry of Transport set the value of life at $2.0 million in 1991 dollar values (NZG 1991). This was updated for an injury prevention strategy to $3.35 million at June 2008 prices (Wren and Barrell 2010). At June 2009 prices, the latter equates to $3.42 million, which is the value of (statistical) life adopted for estimating the cost of foodborne disease on WTP criteria in this study.

By making a simplifying assumption that average life expectancy is 40 years; that each remaining year of life is of uniform value; and using the standard compound interest formulae and a discount rate of 3.5% (Grocott et al 2007), it follows that the value of a statistical life year (VOSLY) in 2009 was $159,962.[16] A full year of 100% disability would hence represent a burden of $159,962 or $438 a day ($159,962 ÷ 365). These are the estimated amounts New Zealanders would be willing to pay to avoid a year or day of (total) disability respectively.

2.5.3 Disability associated with foodborne disease

Since most foodborne disease lasts just a few days, it imposes only a small fraction of a year of disability upon households in the year in which it occurs—based on a scale reflecting its severity or disability weight and its duration. Disability weights are measured on spectrum ranging from 0 (indicating perfect health) to 1 (death). The sum of the series of incident cases in a year will thus aggregate into all years of life lived with a disability related to foodborne disease.

Table 9: Foodborne disease: duration & severity of disability & cost per incident case, 2009

Disease /manifestation	Days of disability per case[1]	Disability weight[2] (0 = perfect health; 1 = death)	WTP cost per case, $s (Disability weight × days × $438)
GE, self care	3	0.067	88
GE, GP care	10	0.393	1,722
GE, Inpatient care	14	0.393	2,411
GBS, mild (F2)[3]	365	0.2	31,992
GBS, severe (F4)[3]	365	0.8	127,970
ReA	42	0.21	3,865
ReA, Inpatient care	183	0.37	29,674
IBD	183	0.26	20,852
HUS	30	0.056	736
ESRD	365	0.328	52,468
Listeriosis[4]	183	0.42	33,684

[1] Cressey and Lake (2009 Table 3 p 11)
[2] Cressey and Lake (2007 Table p 11)
[3] 'F' values refer to functional score
[4] Complicated episode of diarrhoeal disease (Mathers et al 1999 p 186)

[16] $\$159,962/1.035 + \$159,962/(1.035)^2 \ldots + \$159,962/(1.035)^{40} = \$3,416,000$

A list of disability weights for manifestations of foodborne diseases, together with the respective expected duration of the disability is given in Table 9. Severity weights associated with manifestations are based on the work of Cressey and Lake (2007) who borrow or adapt from work in other countries (notably the Netherlands). NZFSA advised at the time of writing that these weights were suitable for use in New Zealand (Abelson 2010).

Thus, for example, in New Zealand an uncomplicated case of campylobacteriosis or salmonellosis manifesting as GE managed by a GP, could be expected to be associated with 10 days of infirmity, during which time the person infected would incur a loss equivalent to a departure of 0.393 from perfect health, etc. Duration of a disability bears some relationship work days lost (Table 8), but generally exceeds work time lost, indicating that people may return to work before their symptoms may have completely subsided. Days of disability for each manifestation follow Cressey and Lake (2009) and are also borrowed from elsewhere.

2.5.4 Calculation of the burden of disease cost

It follows from the above that a valuation of the burden of years lived with disabilities associated with 2009 incident cases of foodborne disease, will derive from the cost of the aggregate number of less-than-healthy years of living, represented by the product of:

- the number of incident cases for each disease, distributed between manifestations and levels of severity;
- the disability weight specific to each manifestation according to its severity;
- the likely duration of each manifestation according to severity (measured in days) ; and
- the value of a statistical life day of full health ($438).

It will be noted from the right hand column of Table 9 that New Zealanders would have been willing to pay amounts ranging from $127,970 to avoid contracting a severe case of GBS to $88, to avoid a bout of self-treated GE.

During 2009, foodborne disease also appears to have been responsible for 12 premature deaths (four each from STEC, salmonellosis and listeriosis) (Table 1). The cost of each death must also be included in the burden of foodborne disease. This will be equivalent to the product of the number of lives lost and the VOSL ($3.42 million).

A full accounting for WTP losses may hence be summarised as the burden of disability-adjusted life years (DALYs) accumulated as the sum of 2009 incident cases, represented by the aggregate of years of healthy years of life lost due to:

- life in states of less than full health or disability (YLD); and
- premature mortality (YLL) (Havelaar 2007).

Central estimates of these values are summarised in Table 10 (on page 28), from which it will be seen that the total WTP value to avoid foodborne disease in 2009 was $127 million. The most important single source of this cost was premature mortality, which constituted the major part of the costs of listeriosis ($14.4 million), salmonellosis ($13.7 million) and STEC ($12.6 million).

Although it is not possible to confirm that all deaths were caused by foodborne causes, there is a presumption that the four listeriosis deaths were likely to have been foodborne, as food was the source of 87% of listeriosis cases (Lim et at 2010). As for the eight other deaths, the present state of the data on deaths is provisional, based on case reporting and therefore not necessarily complete. No other information was available to the Consultant at the time writing. More deaths could come to light as the release of coroners' reports is often subject to considerable delay. Moreover, as in the case of all

Table 10: Central estimates of willingness to pay to avoid foodborne disease, 2009

Disease / manifestation / severity			No incident cases, 2009	WTP Cost, $ million[1]
Campylobacteriosis	GE	Self care	25,551	2.25
		Ambulatory	14,122	24.32
		Inpatient care	511	1.23
	Mild GBS	Inpatient care	2	0.06
	Severe GBS	Inpatient care	35	4.48
	ReA	Self care	819	0.00
		Ambulatory	183	0.71
		Inpatient care	23	0.68
	IBD	Ambulatory	13	0.02
		Inpatient care	3	0.06
Total campylobacteriosis			41,262	33.82
Salmonellosis	GE	Self care	1,971	0.17
		Ambulatory	617	1.06
		Inpatient care	94	0.23
	ReA	Self care	46	0.00
		Ambulatory	11	0.04
		Inpatient care	1	0.03
	IBD	Ambulatory	1	0.02
		Inpatient care	0	0.00
	Death[3]		4	13.66
Total salmonellosis			2,742	15.22
Norovirus	GE	Self care	116,037	10.22
		Ambulatory	21,848	37.63
		Inpatient care	319	0.77
Total norovirus			138,204	48.62
Yersiniosis	GE	Self care	3,867	0.34
		Ambulatory	741	1.28
		Inpatient care	45	0.11
	ReA	Self care	37	0.00
		Ambulatory	8	0.03
		Inpatient care	1	0.03
Total yersiniosis			4,699	1.79
STEC	GE	Self care	111	0.01
		Ambulatory	92	0.16
		Inpatient care	1	0.00
	HUS	Inpatient care	5	0.00
	ESRD	Inpatient care, Yr 1	1	0.05
		Yr 2 +[2]	1	0.25
	Deaths[3]		4	12.64
Total STEC			210	13.11
Listeriosis	Acquired	Inpatient care	15	0.51
	Perinatal	Inpatient care	8	0.27
	Deaths[3,4]		4	13.66
Total listeriosis			23	14.44
TOTAL				127.00

[1]WTP cost per case (Table 9) × No 2009 incident cases [2]NPV @ 3.5%, 10- year survival [3]@ $3.416 million
[4]Years of survival (@40) averaged across 2 p-natal deaths (years survival >40) & 2 deaths 70+ (years of survival <40)

evidence on incident cases, mortality data are scaled and need to be interpreted cautiously as they cannot purport to embody a high degree of precision.

Table 10 shows that norovirus was the disease with manifestations most prolifically associated with disability and the most important single source of the burden of disability—accounting for WTP costs to avoid disability of $48.6 million. Campylobacteriosis was the other main source of disability cost ($33.8 million), mainly attributable to levels of severity greater than for norovirus, but distributed across many fewer cases.

2.6 Residual lifestyle costs

Table 11 compares loss of output and WTP valuations of foodborne disease. As discussed above, the difference between WTP valuations ($127 million) and output costs ($27.3 million) represents a residual private lifestyle loss, which amounts to an aggregate of $99.7 million.

Table 11: Central estimates of residual private lifestyle cost attributable to foodborne disease, 2009, $ million

Cost	Campylo-bacteriosis	Salmonellosis	Norovirus	Yersiniosis	STEC	Listeriosis	Total
Output loss	17.82	0.36	7.66	1.06	0.35	0.06	27.32
WTP value	33.82	15.22	48.62	1.79	13.11	14.44	127.00
Residual private costs	16.00	14.85	40.96	0.73	12.76	14.38	99.67

In keeping with what might be expected in reasoning from general economic principles, Table 11 reveals that WTP values for each one of the diseases exceeds the value of its output loss, indicating in each case the existence of a residual lifestyle loss. This is consistent with disability weights that fully reflect the private burden of disease, equivalent to the respective margins by which WTP values in each case exceed values of paid days lost—i.e. $16 million in the case of campylobacteriosis ($33.8 million *minus* $17.8 million), etc.

3 Total cost of foodborne disease

This section brings together all costs associated with foodborne disease. Table 12 accordingly summarises total costs for each of the foodborne diseases in 2009. It distinguishes between costs of government regulation and surveillance and costs of industry compliance and costs that are associated with the frequency, type and progression of incident cases. In 2009, the central estimate for the grand total cost of all foodborne disease, including government, industry and incident case costs is $161.9 million.

Table 12: Central estimates of present values of total costs of foodborne diseases, 2009, $ million

Cost	Campylo-bacteriosis	Salmonellosis	Norovirus	Yersiniosis	STEC	Listeriosis	Total
Government outlays	§	§	§	§	§	§	16.40
Industry costs[1]	§	§	§	§	§	§	12.30
Treatment costs	2.17	0.20	1.45	0.12	1.51	0.74	6.19
Output loss	17.82	0.36	7.66	1.06	0.35	0.06	27.32
Residual private costs	16.00	14.85	40.96	0.73	12.76	14.38	99.67
Total, excl govt. & ind.	*36.00*	*15.41*	*50.07*	*1.90*	*14.63*	*15.18*	*133.19*
Grand total	-	-	-	-	-	-	***161.90***

§Totals not apportioned to individual diseases
[1]Excludes undocumented business compliance costs covering Food Safety Programmes and their implementation

3.1 Source of foodborne disease costs

The final column of Table 12 shows that aggregate incident case costs are distributed between residual private costs of nearly $100 million or about 62% of grand total cost; output loss of $27 million, about 17% of grand total cost; and treatment costs of $6 million (4%).

Combined government outlays and industry costs may jointly account for about 18% of the grand total cost—with government outlays of some $16 million, representing 10% and industry costs of about $12 million (8%).

Due to its volume of cases, norovirus represents the largest single source of case cost (i.e. excluding costs to government and industry), amounting to some $50 million or 38% of all incident cases costs. As discussed elsewhere, however, much of the norovirus experience is unrecognised by the health system; it is without complications and its foodborne component may be subject to significant standard error.

Campylobacteriosis is the most costly recognisable foodborne disease, amounting to $36 million or 27% of all disease-specific costs—followed by salmonellosis ($15 million, 12%) and listeriosis (15 million, 11%)—which, despite its low volume, has a high cost per case, reflecting a potential for serious complications and a high risk of premature death.

The cost of STEC is driven largely by the risk of rare but severe complications and premature death (nearly $15 million, 11%). Although yersiniosis is a disease of greater frequency than STEC, its complications are few and its cost is of minor consequence ($2 million, 1%).

3.2 Sensitivity for discount rate

In most studies evaluating the cost of disease, future costs are discounted to reflect that they are less important than in the present. As most effects of incident case costs of foodborne disease are restricted to within a few days of infection, their total cost is generally insensitive to the choice or variation of discount rate.

The discount rate of 3.5% used in the estimation of total cost shown in Table 12 is that recommended by Grocott et al (2007) for use by PHARMAC in evaluating the cost-effectiveness of pharmaceuticals. This rate is an approximation of the five-year average real, risk-free government bond rate and is designed to reflect the social opportunity cost of capital.

To accommodate for possible uncertainty concerning the opportunity cost of capital, Table 13 compares use of the 3.5% base rate of with rates of 0%, 5% and 10%, as recommended by Grocott et al (2007). A zero discount rate is included in the comparison, as advocated by some public health practitioners in evaluating public health programmes.

Table 13: Sensitivity of central estimates of present values of the incident case cost of foodborne disease cost to rate of discount, $ million, 2009

Discount rate	Campylo-bacteriosis	Salmonellosis	Norovirus	Yersiniosis	STEC	Listeriosis	Total
0.0%	36.05	15.41	50.07	1.90	14.94	15.18	133.56
3.5%	36.00	15.41	50.07	1.90	14.63	15.18	133.19
5.0%	35.98	15.41	50.07	1.90	14.52	15.18	133.06
10.0%	35.94	15.41	50.07	1.90	14.23	15.18	132.73

For diseases other than STEC, discount rates exceeding 3.5% have little or no effect, as their costs are likely to accrue mostly in 2009. Where enduring complications of campylobacteriosis and salmonellosis ensue, their minor downstream costs are subject to further discount, which is responsible for slight reductions in the overall present values for these diseases. For exceptional cases of STEC, downstream costs associated with the risk of ESRD are significant, with the result that for 2009, higher discount rates cause a variance in present values of up to some 3% relative to the base discount rate.

3.3 Discussion

The major sources of cost are the frequency of diseases such as norovirus and campylobacteriosis and the high costs per case for listeriosis and in some instances, STEC.

Table 14: Indicators of the comparative cost of foodborne disease in New Zealand

Central measure of cost	New Zealand, 2009[1]	Australia, 2002[1]	Ohio (USA), 2001 -05[1]
Total incident case cost	$133.19m	AUD1,225m	USD4,100m
Total incident case cost per person	$31	AUD64	USD355
Cost of GE per person[2]	$19.16	AUD51.42	-
Cost of campylobacteriosis per person[3]	$8.30	-	USD18.82
Cost of salmonellosis per person[4]	$3.55	-	USD19.77
Cost of listeriosis per person[5]	$3.43	AUD4.35	USD23.72

Source: Abelson et al (2006); Scharff et al (2009)
[1]@2009 values for NZ; 2004 values for Australia; 2007 values for Ohio
[2]Uncomplicated GE = 99% of foodborne cases in NZ and 98% in Australia
[3]Campylobacteriosis = 22% of foodborne cases in NZ and 14% of ‘known agents’ in Ohio
[4]Salmonellosis = 1% of foodborne cases in NZ and 10% of ‘known agents’ in Ohio
[5]Listeriosis = 0.01% of foodborne cases in NZ, 0% in Australia and 0.04% of ‘known agents’ in Ohio

Table 14 provides illustrative summary indicators of the cost of foodborne disease in New Zealand, and compares them with ones for Australia and the US State of Ohio. Comparison is easiest with Ohio, where the classification for reporting is similar to New Zealand’s and where the six diseases of this study represent 89% of the ‘known’ Ohio experience (Scharff et al 2009). Although Australia’s classification differs from New Zealand's, the six diseases in this study represent 99% of cases covered in Abelson et al (2006)[17].

The way in which case cost per person is tabulated shows that for Ohio it is possible to compare cost, disease by disease; but for Australia—because campylobacteriosis is not notifiable in the New South Wales jurisdiction—it is necessary to use uncomplicated GE as the comparator for most diseases.

On a variety of criteria, evidence in Table 14 suggests that New Zealand's relative cost of foodborne disease may be lower than in comparable places. Its low-cost 2009 experience compared to Australia's of 2002 may be explained in part by the fall in number of cases of GE—and campylobacteriosis in particular since the mid-2000s (discussed further below). Other possible explanations include:

- an estimated crude mortality rate from foodborne disease in New Zealand (0.002 per 1,000) some three times lower than in Australia (0.006 per 1,000)—which despite a higher 2009 dollar valuation of life (than Australia's in 2004) would have further moderated New Zealand's residual loss (although the accounting for mortality was different in the Australian study); and
- New Zealand's relatively low wage costs—$140 per day in 2009 as against a 2004 cost of AUD175 used for Australia.

The aggregate estimated incident case cost in 2009 of $133.2 million is higher than the central estimate of Cressey and Lake (2008) for 2005 of $85.3 million. This may be explained partly by Cressey and Lake not taking account of private residual lifestyle cost (although they include private treatment and transport costs).

On the other hand, Cressey and Lake's estimate appears high if it is compared simply with our treatment and loss of output cost of $34 million (Table 12). This may reflect that between 2006 and 2009, annual estimated incident cases of foodborne campylobacteriosis fell from about 87,000 to some 41,000 (Pirie et al 2008, Table 7; Table 1 above). Whereas norovirus appears to have increased, it is mostly self-treated (and less costly) and evidence as to the extent of its foodborne source is more open to question. The fall in the treatment and loss of output component of cost attributable to campylobacteriosis between 2006 and 2009, however, would have been of the order of $22 million (46,000 cases × $485)—but still insufficient to fully explain the difference.

The arrest in incident cases of campylobacteriosis may be seen in the light of the impact of the new regulatory environment associated with the Government's Poultry Risk Management Strategy (Sears et al forthcoming). Combined estimated government and industry costs associated with implementing this strategy during 2009 are $3.25 million. This may be compared with estimated savings in total case costs of campylobacteriosis in 2009 (i.e. including residual lifestyle costs) of $40 million (46,000 cases × $871, the aggregate unit cost per campylobacteriosis case at 2009 prices).

Since combined government and industry expenditures may have represented about 18% of total foodborne disease cost in 2009, it perhaps may be interpreted as evidence of the capacity of the food industry to incorporate them in its margins. However, these mainly fixed costs need more properly to be assessed in relation to the significant incremental cost they may have averted, rather than in the context of their current (relatively low) share of total cost.

Our calibration of cost, nevertheless, must be interpreted with care as it embodies uncertainties arising from imperfect measurements and approximations that have been necessary to the modelling. For instance, attributing value to preventing premature loss of a human life or avoiding disability is not an

[17] The minor difference between disease coverage in this study and the Abelson et al (2006) study for Australia is because New Zealand either has no corresponding foodborne agent (toxoplasmosis) or possesses no evidence as to foodborne causes (hepatitis A) (Lim et al 2010).

exact science, yet it remains a significant source of economic gain in reducing the burden of foodborne disease.

Furthermore, variability in values of inputs derives from causes that include:

- incident cases of disease and mortality (except for listeriosis) modelled with values derived from the application of notional multipliers to laboratory confirmed notifications and deaths notified to date;

- the uncertain aetiology of gastrointestinal diseases, with proportions attributable to foodborne causes often speculative;

- the risk of frequencies of treatment services, their disposition and their unit prices deviating significantly from those on which the cost model relies—with a potential to cause actual unit case costs of treatment to differ from the central estimates used in the modelling;

- lost paid days and days of disability per case being approximations; and

- information about costs to industry relying on piecemeal evidence.

We have accordingly restricted reporting values to central estimates since confidence intervals would have required iterative application of multiple variance operators. This would have introduced large, arbitrary and unhelpful standard errors[18].

Modelling foodborne disease can reveal strikingly different results according to the design of the model, the assumption made about valuing inputs and the source of data. Although the results of this model rely upon the best information available, they need to be interpreted with caution.

[18] For instance, recent work on disease multipliers in the UK illustrates the magnitude of variances that can be expected. Examples of credible interval ranges at the 95% level for disease multipliers include campylobacteriosis 9.3 (6.0 – 14.4), STEC 7.4 (0.5 – 104.4), salmonellosis 4.7 (1.2 – 18.2) and norovirus 287.6 (239.1 – 346); personal communication, Dr Donald Campbell, NZFSA.

Appendix 1: Distribution of incident cases of foodborne disease in New Zealand in 2009 according to manifestation and severity

DISEASE	MANIF-ESTATION	SEVERITY	% TOT CASES	TOTAL CASES	Type and frequency of treatment per incident case										
					2009							Later years, per year			
					GP	Presc	Allied	Spec	Lab	Dial	Hosp	Allied	Spec	Dial	Hosp
Campylobacteriosis	GE	Self care	61.9%	25,551											
		Ambulatory	34.2%	14,122	1	0.581			0.416						
		Inpatient care	1.2%	511	1	0.581			1		1.05				
	Mild GBS	Inpatient care	0.0%	2	1		16.7	2			2.35				
	Sev GBS	Inpatient care	0.1%	35	1		42	3			2.35	6[1]			
	ReA	Self care	2.0%	819											
		Ambulatory	0.4%	183	1	0.33			1						
		Inpatient care	0.1%	23	1	0.33			1		1.34				
	IBD	Ambulatory	0.0%	13	1	11.2		2	1				2[2]		
		Inpatient care	0.0%	3	1	12		2	1		2.4		2[2]		
Total campylobacteriosis			100.0%	41,262											
Campylobacteriosis deaths				0											
Salmonellosis	GE	Self care	71.9%	1,971											
		Ambulatory	22.5%	617	1	0.581			0.416						
		Inpatient care	3.4%	94	1	0.581			0.416		1				
	ReA	Self care	1.7%	46											
		Ambulatory	0.4%	11	1	0.33			1						
		Inpatient care	0.0%	1	1	0.33			1		1.34				
	IBD	Ambulatory	0.0%	1	1	11.16		2	1				2[2]		
		Inpatient care	0.0%	0	1	11.16		2	1		2.4		2[2]		
Total salmonellosis			100.0%	2,741											
Salmonellosis deaths				1											
Norovirus	GE	Self care	84.0%	116,037											
		Ambulatory	15.8%	21,848	1	0.581			0.004						
		Inpatient care	0.2%	319	1	0.581			0.004		1				
Total norovirus			100.0%	138,204											

DISEASE	MANIF-ESTATION	SEVERITY	% TOT CASES	TOTAL CASES	Type and frequency of treatment per incident case										
					2009							Later years, per year			
					GP	Presc	Allied	Spec	Lab	Dial	Hosp	Allied	Spec	Dial	Hosp
Campylobacteriosis	GE	Self care	61.9%	25,551											
		Ambulatory	34.2%	14,122	1	0.581			0.416						
		Inpatient care	1.2%	511	1	0.581			1		1.05				
	Mild GBS	Inpatient care	0.0%	2	1		16.7	2			2.35				
	Sev GBS	Inpatient care	0.1%	35	1		42	3			2.35	6[1]			
	ReA	Self care	2.0%	819											
		Ambulatory	0.4%	183	1	0.33			1						
		Inpatient care	0.1%	23	1	0.33			1		1.34				
	IBD	Ambulatory	0.0%	13	1	11.2		2	1				2[2]		
		Inpatient care	0.0%	3	1	12		2	1		2.4		2[2]		

DISEASE	MANIF-ESTATION	SEVERITY	% TOT CASES	TOTAL CASES	Type and frequency of treatment per incident case										
					2009							Later years, per year			
					GP	Presc	Allied	Spec	Lab	Dial	Hosp	Allied	Spec	Dial	Hosp
Yersiniosis	GE	Self care	82.3%	3,867											
		Ambulatory	15.8%	741	1	0.581			0.416						
		Inpatient care	1.0%	45	1	0.581			0.416		1				
	ReA	Self care	0.8%	37											
		Ambulatory	0.2%	8	1	0.33			1						
		Inpatient care	0.0%	1	1	0.33			1		1.34				
Total yersiniosis			100.0%	4,699											
Yersiniosis deaths			100.0%	0											
STEC	GE	Self care	52.9%	111											
		Ambulatory	43.8%	92	1	0.581			0.416						
		Inpatient care	0.5%	1	1	0.581			0.416		1				
	HUS	Inpatient care	2.4%	5	1		1				2.27				
	ESRD	Inpatient care	0.5%	1				4		182	4.1		4[3]	182[3]	4[3]
Total STEC			100.0%	210											
STEC deaths				1											

DISEASE	MANIF-ESTATION	SEVERITY	% TOT CASES	TOTAL CASES	Type and frequency of treatment per incident case										
					2009							Later years, per year			
					GP	Presc	Allied	Spec	Lab	Dial	Hosp	Allied	Spec	Dial	Hosp
Campylobacteriosis	GE	Self care	61.9%	25,551											
		Ambulatory	34.2%	14,122	1	0.581			0.416						
		Inpatient care	1.2%	511	1	0.581			1		1.05				
	Mild GBS	Inpatient care	0.0%	2	1		16.7	2			2.35				
	Sev GBS	Inpatient care	0.1%	35	1		42	3			2.35	6[1]			
	ReA	Self care	2.0%	819											
		Ambulatory	0.4%	183	1	0.33			1						
		Inpatient care	0.1%	23	1	0.33			1		1.34				
	IBD	Ambulatory	0.0%	13	1	11.2		2	1				2[2]		
		Inpatient care	0.0%	3	1	12		2	1		2.4		2[2]		
Listeriosis	Acquired	Inpatient care	65.2%	15	1						1.37				
	Perinatal	Inpatient care	34.8%	8							1.37				
Total listeriosis			100.0%	23											
Listeriosis deaths				4											

Source: ESR, personal communication
[1]In year 2 only
[2]Rest of lifetime care (additional 39 years)
[3]Rest of lifetime care (additional 9 years)

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