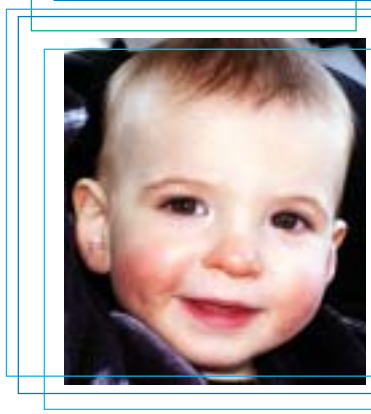
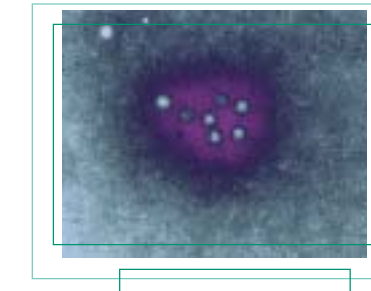
Australian Government
Department of Health and Ageing

Foodborne illness in Australia

Annual incidence circa 2000





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Contents

Executive summary

Australia invests considerable effort in ensuring a safe food supply. However, there has been little information available about the incidence and causes of foodborne illness to help governments develop policies in this area. This study represents the most comprehensive survey and analysis of the incidence of foodborne illness in Australia.

The nature and complexity of foodborne illness mean that it is hard to get good data. Many foodborne illnesses are not recognised by health professionals as 'foodborne', nor are they reported to health authorities conducting public health surveillance.

Gastroenteritis is a common form of foodborne illness. OzFoodNet and the National Centre for Epidemiology and Population Health at The Australian National University conducted a national gastroenteritis survey during 2001 and 2002. Data from this survey which related to foodborne gastroenteritis were combined with other data on foodborne illnesses to give the total incidence of foodborne illness in Australia.

The National Gastroenteritis Survey results showed that there are approximately 17.2 million cases of gastroenteritis in Australia each year, including infections from sources other than food. Young children and adult carers reported the highest rates of gastroenteritis. Residents of the Northern Territory, both Indigenous and non-Indigenous, had a higher incidence of gastroenteritis than residents of the other states and territory. Gastroenteritis was most common in summer and winter, and it was reported more often by those on higher incomes.

Of the 17.2 million cases of gastroenteritis in Australia each year, 5.4 million (32%) were estimated to originate from contaminated food, with a 95% credible interval of 4.0–6.9 million cases. The most common pathogens responsible for foodborne gastroenteritis were pathogenic *E. coli*, norovirus, *Campylobacter* and non-typhoidal *Salmonella*. The annual effects of foodborne gastroenteritis were considerable, resulting in an estimated:

- 1.2 million people visiting the doctor
- 300,000 prescriptions for antibiotics
- 2.1 million days of work lost every year.

In addition, there were an estimated 6,000 cases of acute foodborne illness other than gastroenteritis. These included some serious illnesses, such as invasive listeriosis, where 20% of infections are fatal.

Foodborne gastroenteritis may result in sequelae, where other consequences arise from an initial acute infection. It was estimated that there were approximately 42,000 episodes of illnesses following foodborne gastroenteritis in Australia each year. These included illnesses such as reactive arthritis, irritable bowel syndrome and Guillain-Barré syndrome.

Although foodborne gastroenteritis is often mild, significant numbers of people are hospitalised. This study estimated that, each year in Australia, foodborne illness resulted in about 15,000 hospital admissions for gastroenteritis, 170 for other acute illnesses and 2,900 for sequelae following gastroenteritis, and about 120 people died due to foodborne illness.

The estimates derived from the National Gastroenteritis Survey and other data provide a 'snapshot' of the incidence of foodborne illness for one year circa 2000. Revised estimates based on future surveys and increased knowledge of the causes of foodborne illness will lead to an increasingly complete picture of the burden of foodborne illnesses. This study clearly demonstrates that these illnesses are a significant public health problem and justify the attention given to surveillance of foodborne illnesses and food safety in Australia.

Acknowledgments

The Australian Government Department of Health and Ageing thanks the many people who helped with the conduct of this study and production of this report.

The Communicable Diseases Network Australia provided data from the National Notifiable Diseases Surveillance System on notifications of infectious causes of gastroenteritis. State and territory health departments and laboratories provided data on various causes of foodborne illness. The Australian Institute of Health and Welfare provided data relating to hospitalisations and deaths.

This report is based on work conducted by Dr Gillian Hall and the OzFoodNet Working Group under contract to the Australian Government Department of Health and Ageing.

This study was funded by the Australian Government Department of Health and Ageing.

Dr John Marshall from the Victorian Infectious Diseases Reference Laboratory supplied the electron micrograph of norovirus particles in faeces on the front cover.

Further information

The methods and results of this work are presented in summary form in this report. Further details on the National Gastroenteritis Survey and the estimation of foodborne illness can be found at < http://nceph.anu.edu.au/Publications/working_papers.php > .

Background

In 1995, mettwurst contaminated with *E. coli* O111 caused a severe outbreak of foodborne illness that affected over 170 people in South Australia. Twenty-three children developed haemolytic uraemic syndrome and one child died (Cameron et al. 1995).

Within months of this South Australian outbreak, Health Ministers from across the country asked the then National Food Authority, now Food Standards Australia New Zealand, to develop new national food safety standards. The prevailing state and territory food hygiene regulations were outdated, nationally inconsistent, overly prescriptive and out of step with those of Australia's trading partners (Australia New Zealand Food Authority 1999).

Health Ministers first considered four draft standards[1] in October 1999, at a meeting of the Australia New Zealand Food Standards Council. At that meeting, adoption of Food Safety Standard 3.2.1 *Food Safety Programs* was put on hold due to concerns raised by some government agencies, food business groups, charities and community organisations. Central to their concerns was the need for comprehensive data on the incidence and causes of foodborne illness in Australia, and a more thorough examination of the relevance and impact of mandatory food safety programs. Ministers subsequently asked the Australian Government to address these concerns through a work program on food safety coordinated by the Australian Government Department of Health and Ageing.

Among other initiatives, the work program led to the formation in 2000 of a national system to enhance foodborne illness surveillance, OzFoodNet. OzFoodNet is a national network of epidemiologists who work within state and territory health departments. The role of OzFoodNet is to determine the burden and causes of foodborne illness in Australia, and to coordinate national investigations of foodborne illness. The network includes many different government departments and other agencies responsible for surveillance and control of foodborne illness.

OzFoodNet and the National Centre for Epidemiology and Population Health conducted a national survey during 2001 and 2002 to estimate the incidence of gastroenteritis. This was combined with data from several other sources to estimate the incidence and impact of foodborne illness in Australia, as described in this report.

Estimating the incidence of foodborne illness in Australia

It is very difficult to quantify the true incidence of foodborne illness in the community. Most people who become ill from eating contaminated food experience symptoms of gastroenteritis, which may be caused by a wide variety of different

1 Food Safety Standard 3.1.1 *Interpretation and Application*
Food Safety Standard 3.2.1 *Food Safety Programs*
Food Safety Standard 3.2.2 *Food Safety Practices and General Requirements*
Food Safety Standard 3.2.3 *Food Premises and Equipment*.

pathogens. Contaminated food can also cause a number of other types of illnesses, such as meningitis, septicaemia, neurological conditions and hepatitis. In addition, certain illnesses can occur as a delayed reaction to an episode of acute gastroenteritis. These sequelae include reactive arthritis, irritable bowel syndrome and Guillain-Barré syndrome (see Appendix 1).

Gastroenteritis and other illnesses can also be acquired from a range of sources in addition to food, such as directly from contact with infected animals, contaminated water, the environment or other ill people. The time between infection and the development of symptoms can vary from a few hours to weeks. These factors make it difficult to determine the proportion of cases of a particular illness that result from eating contaminated food. The actual source of a person's infection is usually only identified during outbreak investigations, where epidemiological inquiry establishes that different patients have eaten common foods.

Australian states and territories conduct routine surveillance for certain illnesses that may be acquired from contaminated food. Legislation requires doctors and laboratories to report or notify certain infections to the health department, which includes *Salmonella*, *Campylobacter*, *Shigella* and Shiga toxin producing *E. coli*. These surveillance systems are mainly focused on monitoring the incidence of specific infections or detecting outbreaks.

However, most cases of gastroenteritis are mild and self-limiting. This means that many people suffering gastroenteritis do not visit a doctor or submit a specimen for testing. In addition, there are many foodborne illnesses that doctors and laboratories are not required to report to health departments. Norovirus is one of the most common known causes of gastroenteritis in the developed world, but laboratories do not routinely test stool specimens for this organism and doctors are not required to notify health departments.

Studies from other countries show that for every infection reported to a surveillance system there are many undetected cases in the community (Mead et al. 1999; Wheeler et al. 1999). The proportion of cases reported to health authorities varies depending on the pathogen causing the illness. Organisms such as *Salmonella* cause a more severe illness, meaning that patients are more likely to seek medical care and get tested (Voetsch et al. 2004). Laboratories and doctors consequently report a higher proportion of *Salmonella* infections to health authorities than milder illnesses, such as those caused by viruses (Wheeler et al. 1999; Yohannes 2002; Voetsch et al. 2004).

There have been previous Australian surveys to estimate the total incidence of gastroenteritis in the community. These have included the national health surveys conducted by the Australian Bureau of Statistics in 1989 and 1995 (Australian Bureau of Statistics 1991, 1997). A follow-up study into community gastroenteritis in a localised area of Melbourne—the Water Quality Study—was conducted by the Cooperative Research Centre for Water Quality and Treatment between 1997 and 1999 (Hellard et al. 2001). However, these studies explored gastroenteritis in a limited way or were focused on specific issues. None of these studies attempted to estimate what proportion of gastroenteritis in the community may have been due to food.

The National Gastroenteritis Survey detailed in this report was designed to provide a more accurate picture of this common illness in Australia. As the incidence of gastroenteritis is known to vary by geography and season, the National Gastroenteritis Survey covered the whole country over a 12-month period during 2001 and 2002.

A different approach was used to assess the burden of illness for other foodborne illnesses, such as invasive listeriosis, hepatitis A infection and ciguatera, and to assess sequelae such as Guillain-Barré syndrome. Data for these illnesses was obtained from notifiable illness registers, hospitalisation statistics and other sources.

This report estimates the number of cases, hospitalisations and deaths for gastroenteritis and other illnesses acquired from contaminated food in Australia for one year circa 2000.

Methods

The annual incidence of foodborne illness in Australia was estimated using a modification of methodology used in the United States of America (Mead et al. 1999). First, the level of gastroenteritis was determined and then an estimate was made of the proportion of this gastroenteritis that was transmitted by food. This approach was then repeated for other non-gastroenteritis illnesses and recognised sequelae following gastroenteritis. A similar approach was used to estimate the number of hospitalisations and deaths from foodborne illness.

There was no precise way to estimate the amount of illness due to contaminated food. Certain parts of the methodology were more prone to uncertainty than others, such as the proportion of illness due to each pathogen that was foodborne. While data were used from outbreaks, these estimates relied on expert opinion. Another area of considerable uncertainty was the estimates for some of the sequelae. The degree of uncertainty arising from limitations in available data was accounted for in the calculations.

Gastroenteritis

Total incidence

To estimate the annual incidence of all gastroenteritis, the National Gastroenteritis Survey was conducted[2] over a 12-month period between September 2001 and August 2002. Randomly generated telephone numbers were used to select the household, and the person with the most recent birthday was selected for interview. Trained interviewers used a technique called 'computer-assisted telephone interviewing', which is a way of recording data directly into a database. Interpreters were provided for certain language groups. The survey did not include people living in institutions, those who were unable to answer the questionnaire for some other reason, or those in households without a land telephone line.

The questionnaire was adapted from a survey developed in the United States (< http://www.cdc.gov/foodnet/ > ; Herikstad et al. 2002). Each person was asked if they had experienced vomiting and/or diarrhoea in the previous four weeks. If they had reported these symptoms, they were then asked about their illness, use of health care facilities, any medical investigations and treatment that they received, and the effect of their illness on work and usual activities. Demographic information, socioeconomic status and any history of chronic illness were also sought from respondents.

The definition of gastroenteritis used in the analysis of the survey data includes both mild and more serious cases of gastroenteritis. A more restrictive case definition would include only cases with more severe illness, while a more inclusive one would include more cases with mild symptoms.

2 The National Centre for Epidemiology and Population Health conducted the survey in conjunction with OzFoodNet. Harrison Health Research Pty Ltd collected the data for the survey.

The definition used in the survey was:

- three or more loose stools and/or two or more episodes of vomiting in a 24-hour period
- no known non-infectious cause, such as pregnancy, alcohol or chronic illness
- if respiratory symptoms were also present, four or more loose stools and/or three or more episodes of vomiting in a 24-hour period.

The different definition of gastroenteritis for people reporting respiratory symptoms was used to adjust for cases of illness where the person may have gastrointestinal symptoms as a result of a respiratory infection. Evidence to support this adjustment came from other studies (Monto & Koopman 1980; Leder et al. 2003).

Data were weighted during analysis to make them more representative of the Australian population using a computer program from the Australian Bureau of Statistics.[3] The data were assessed for variation by state, season, age, sex and socioeconomic status. Symptoms, health-seeking behaviour and treatment of cases were also examined, along with an evaluation of time lost from normal activities, work or school. Approval to conduct the study was obtained from the ethics committees of the Australian Government Department of Health and Ageing, The Australian National University, and state health departments.

Foodborne gastroenteritis

The ultimate objective was to estimate the incidence of foodborne gastroenteritis in Australia for one year circa 2000, and the data sources used in this study relate to this time period.

To estimate the proportion of all gastroenteritis due to food, individual 'known' pathogens were studied. There are many different pathogens that cause foodborne gastroenteritis. In this study 16 key microbial pathogens that cause gastroenteritis in Australia were assessed. Infections that were considered rare in Australia, or predominantly reported in travellers returning from overseas, were not included. A complete list of assessed illnesses, their key features, and data sources may be found in Appendix 1.

The steps used to estimate the proportion of gastroenteritis that was 'foodborne' in Australia are shown in Figure 1.

Data were obtained from a variety of sources, including the National Gastroenteritis Survey, the National Notifiable Diseases Surveillance System, laboratory data, the OzFoodNet outbreak register and the National Hospital Morbidity Database, along with published literature and a survey of experts in foodborne illness. The characteristics of the various data sources used in this study are summarised in Appendix 2.

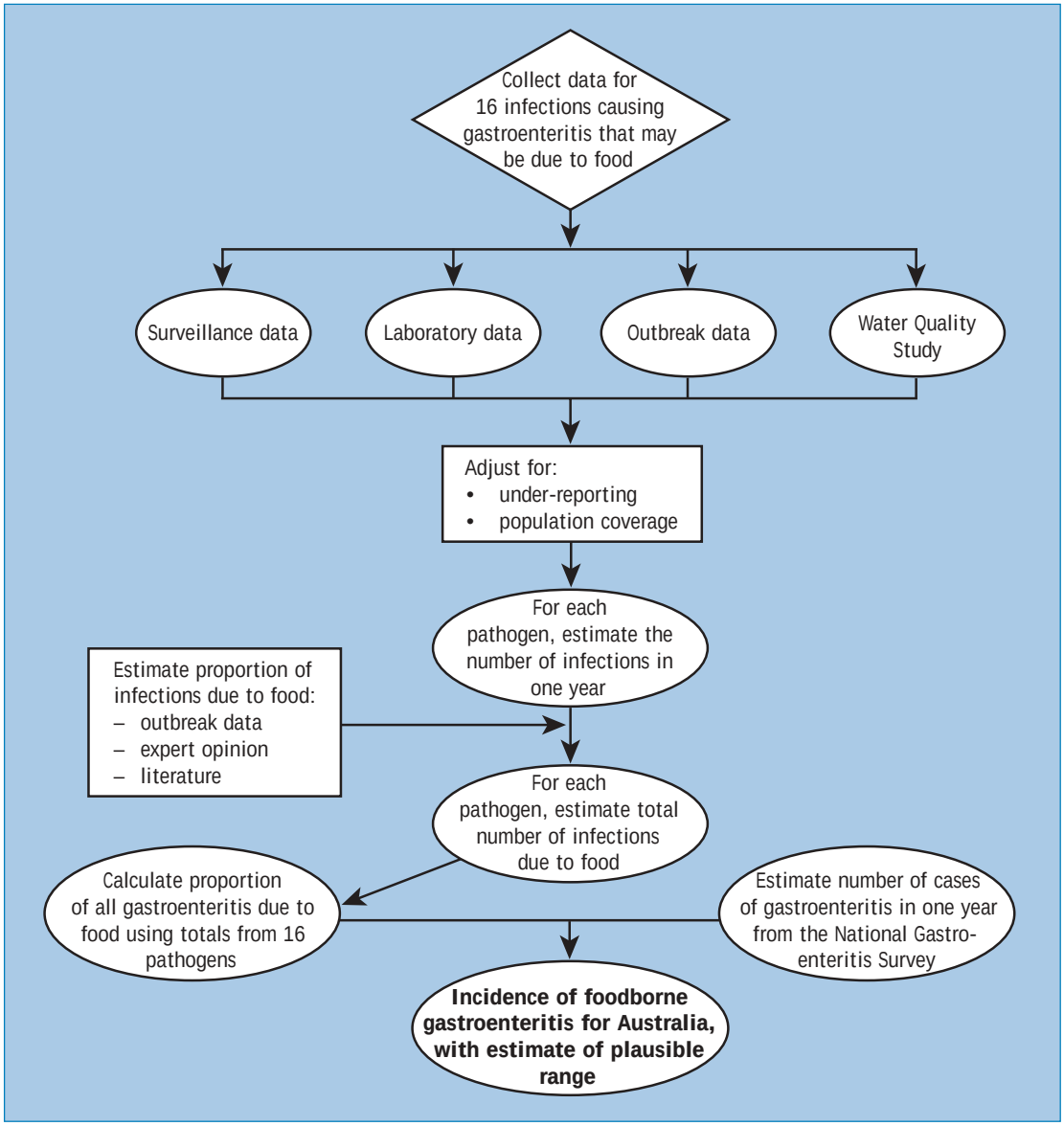
The incidence of illness due to each of the 16 pathogens was estimated. The raw data were adjusted as necessary to account for the proportion of the Australian population that was covered by surveillance or surveys and for infections acquired overseas.

3 Australian Bureau of Statistics, 'Generalized regression estimator method and jackknife approach to estimation of standard errors', program written by P. Bell, Household Surveys Facilities, Canberra.

They were also adjusted for under-reporting, which is the ratio of cases occurring in the community to cases reported to health authorities. The under-reporting factor for each illness was estimated using a variety of information sources, which are detailed in Appendix 3. These data were used to estimate national totals of illness occurring in Australia each year for each pathogen or syndrome.

The proportion of gastroenteritis that was foodborne was then estimated for each individual pathogen. More details of this process are shown in Appendix 4.

Figure 1 **The process for estimating the incidence of foodborne gastroenteritis in Australia**



The number of cases of foodborne illness caused by the 16 'known' pathogens was summed, as was the number of cases of illness estimated to be caused by contaminated food. This then gave an overall proportion of gastroenteritis due to food among these 'known' pathogens. This proportion was then applied to the total number of cases of gastroenteritis determined in the national survey to derive an estimate of the incidence of 'foodborne gastroenteritis for a typical year'.

Other foodborne illnesses and sequelae

The acute non-gastroenteritis illnesses that were assessed as potentially due to contaminated food were hepatitis A, invasive listeriosis, ciguatera intoxication, scombrotoxicosis and toxoplasmosis. Some illnesses that can occur some time after gastroenteritis (sequelae) were also assessed. These included haemolytic uraemic syndrome, Guillain-Barré syndrome, irritable bowel syndrome and reactive arthritis.

Wherever possible, Australian data were used to estimate the annual number of cases of illness for one year circa 2000. Reliable incidence data from Australia were not available for toxoplasmosis and data from the United States were used (Mead et al. 1999). Estimates of the number of foodborne cases of irritable bowel syndrome, reactive arthritis and Guillain-Barré syndrome were based on a combination of Australian data and overseas studies that followed large cohorts of people with gastroenteritis caused by a confirmed pathogen. These studies documented the development of illnesses at a later date in a certain proportion of infected people.

Adjustments were made to the raw data to take into account under-reporting and incomplete population coverage. The proportion of these illnesses due to foodborne transmission was estimated from surveillance data or published studies, and opinions of Australian clinicians and other experts.

Severe foodborne illnesses: hospitalisations and deaths

Hospitalisations for gastroenteritis, non-gastroenteritis illnesses and sequelae following acute gastroenteritis were estimated from the National Hospital Morbidity Database.

For gastroenteritis, data for 1993–94 to 1998–99 were examined using ICD-9-CM codes for gastroenteritis for the principal diagnosis and nine additional diagnoses. Additional diagnoses include cases where gastroenteritis was a contributing factor but not the only reason for hospital admission. These data were used to estimate the average number of hospital diagnoses per year for each of 14 'known' pathogens'.[4] Diagnoses coded as 'gastroenteritis, presumed infectious' were also examined. Adjustments were not made for under-reporting of individual pathogens, since any missed diagnoses for specific pathogens should be included in the unknown 'presumed infectious' category. Death in hospital was determined for separations where gastroenteritis was either a principal or contributing reason for admission.

4 There was no ICD code for *Aeromonas* infection in the hospital separation dataset. Hospitalisations due to *E. coli* infections did not distinguish between different subtypes causing human illness.

For other non-gastroenteritis illnesses and chronic sequelae due to gastroenteritis, estimates of hospitalisations and deaths were derived from several data sources. Data from the National Hospital Morbidity Database were examined for the period 1999–2000 to 2002–03 using ICD-10-AM codes for principal diagnoses only. In addition, data on the hospitalisation dataset were particularly sparse for some illnesses, such as hepatitis A, ciguatera poisoning and listeriosis. In these instances, rates of hospitalisations and deaths were estimated from disease-specific studies and other data sources and applied to incidence estimates. The registered deaths data 1999–2002 held by the Australian Bureau of Statistics were also examined for the equivalent ICD-10 codes for cause of death.

Assessing uncertainty

While the 'best available data' were used in this assessment of the burden of foodborne illness in Australia, there was variation in the availability and quality of the data. This leads to variation in the degree of uncertainty in the estimates of the amount of illness. Much of the uncertainty was inherent in the data itself and not statistical in nature. Simulations were developed to take account of this uncertainty, using the concept of a plausible range of values for Australia for one year circa 2000. The decisions about how to estimate the plausible range of values were based on 'a reasonable interpretation' of real-world data.

Distributions based on the range were used instead of a single value for each component of the calculations used to derive the estimates of incidence, hospitalisations and deaths. The middle 95% of the distributions was used as the 'credible interval'. Throughout this report, the term 'credible interval' (CrI) is used to describe the uncertainty in the estimates. A 95% credible interval means there is a 95% probability that the true value is contained in the interval. Greater uncertainty in data is indicated by a wider credible interval. The 95% credible intervals relating to all tables in the text are shown in the appendixes.

In this report, the estimates are generally reported to two significant figures. The totals for different categories of illnesses may not add up due to rounding.

Findings

National Gastroenteritis Survey

KEY FINDINGS

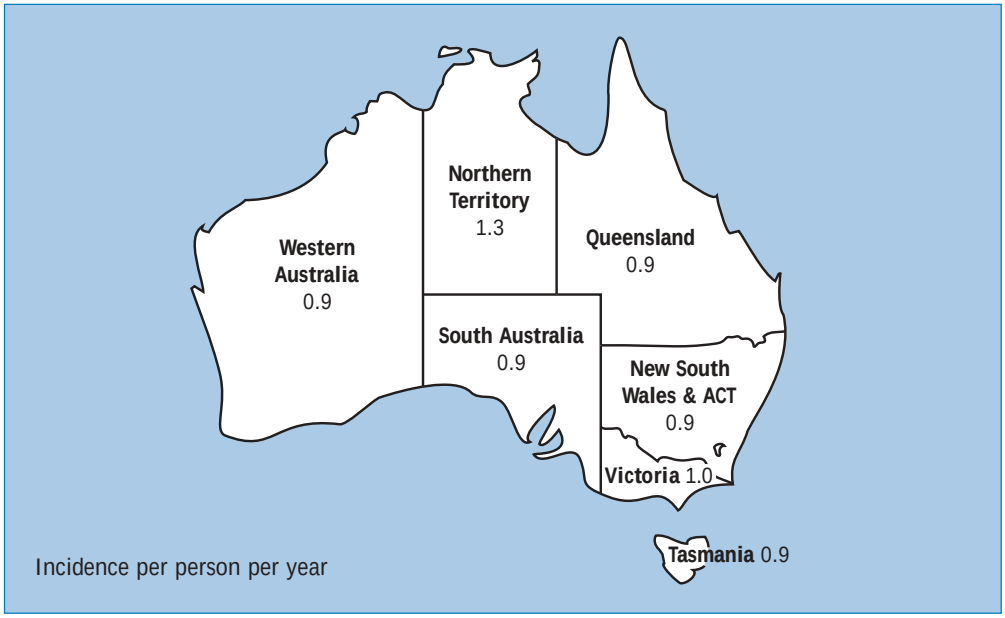
An estimated 17.2 million cases of gastroenteritis occurred in Australia in 2001–02.

This is approximately 0.9 cases of gastroenteritis per person per year.

Of the 6,087 respondents in the National Gastroenteritis Survey, 450 respondents met the primary definition of gastroenteritis. This equates to 17.2 million cases of gastroenteritis in Australia in 2001–02 and approximately 0.9 cases of gastroenteritis per person per year in Australia.

Children under 5 years old and women between 20 and 40 years old reported the most gastroenteritis. The higher rate in 20–40-year-old females was associated with having children with gastroenteritis in their household. The incidence was between 0.9–1.0 episodes per person per year for all states and territories except the Northern Territory, where it was 1.3 cases per person per year (Figure 2). Both Indigenous and non-Indigenous Northern Territory respondents reported higher rates. Gastroenteritis was more common in summer and winter compared with autumn and spring. People with household incomes greater than $100,000 a year were more likely to report gastroenteritis compared with those with lower incomes.

Figure 2 **Incidence of gastroenteritis in Australia, by state and territory, National Gastroenteritis Survey, 2001–02**



More than a quarter of respondents who reported gastroenteritis sought treatment at a health facility, which extrapolates to 4.7 million visits in Australia each year. Of the people with diarrhoea who visited a general practitioner, 22% had a stool test ordered, equating to over 500,000 stool tests submitted in Australia in 2001–02. About 42% of those reporting gastroenteritis took at least one medication, most commonly for pain relief. About 5% of those who reported gastroenteritis were prescribed an antibiotic, which extrapolates to over 900,000 courses of antibiotics in a single year. Approximately 6.5 million days of paid work were lost each year as a result of infectious gastroenteritis.

For further results of the National Gastroenteritis Survey see Appendix 5.

Incidence of gastroenteritis due to food

KEY FINDINGS

An estimated 5.4 million cases of foodborne gastroenteritis occur in Australia each year.

32% of all gastroenteritis may be transmitted via contaminated food.

Most foodborne gastroenteritis is due to unknown pathogens.

Over 80% of foodborne gastroenteritis due to 'known' pathogens is caused by pathogenic *E. coli*, norovirus, *Campylobacter* and non-typhoidal *Salmonella*.

Foodborne gastroenteritis results in about 1.2 million people visiting the doctor, 300,000 prescriptions for antibiotics and 2.1 million days of work lost each year.

In Australia each year, there are an estimated 5.4 million cases of foodborne gastroenteritis with a 95% credible interval of 4.0–6.9 million cases. The incidence is 0.29 cases per person per year, which means that on average Australians suffer one episode of foodborne gastroenteritis every three to four years. Overall, 32% of all gastroenteritis was estimated to be due to foodborne transmission for the 16 'known' pathogens assessed (Table 1). Contaminated food was estimated to cause 58% of bacterial, 21% of viral and 14% of parasitic gastrointestinal infections (see Appendix 6 for details).

Of the 5.4 million cases of foodborne gastroenteritis each year, 1.4 million were estimated to be due to 'known' pathogens. The remainder were due to 'unknown' pathogens, where the pathogen causing the illness was not identified. Four pathogens were responsible for 87% of these foodborne episodes due to 'known' pathogens: pathogenic *E. coli*, norovirus, *Campylobacter* and non-typhoidal *Salmonella*.

Foodborne gastroenteritis was estimated to result in 1.2 million people visiting the doctor and 2.1 million days of work lost each year (Table 2). This relies on the assumption that the severity of gastroenteritis transmitted from food is similar to that for gastroenteritis due to all causes.

Table 1 **Estimated incidence of foodborne gastroenteritis due to 'known' pathogens in Australia for one year circa 2000**

Microbiological agent	% foodborne	Foodborne gastroenteritis
Bacteria		
Aeromonas	25	9,800
Bacillus cereus	100	6,900
Campylobacter	75	208,000
Clostridium perfringens	100	43,000
Shiga toxin producing *E. coli*	65	1,900
Pathogenic *E. coli*	50	563,000
Non-typhoidal *Salmonella*	87	81,000
Shigella	10	300
Staphylococcus aureus	100	14,200
Vibrio parahaemolyticus	71	740
Yersinia enterocolitica	75	1,620
Viruses		
Astro/adenoviruses	10	17,500
Noroviruses	25	446,000
Rotaviruses	2	4,700
Parasites		
Cryptosporidium	10	25,000
Giardia lamblia	5	20,400
Total	**32 (95% CrI: 24–40)**	**1,480,000 (95% CrI: 1,030,000–1,920,000)**

Table 2 **Consequences of foodborne gastroenteritis in Australia for one year circa 2000**

Consequence	Estimated number (millions)	95% CrI
People visiting doctor	1.2	0.7–1.7
Prescribed antibiotics	0.3	0.1–0.5
Stool tests undertaken	0.2	0.0–0.3
Days work lost	2.1	1.2–3.0

Incidence of other foodborne illnesses

KEY FINDINGS

An estimated 6,000 cases of acute foodborne illnesses other than gastroenteritis occur each year.

In Australia each year, contaminated food was estimated to cause about 6,000 cases of illnesses other than gastroenteritis (Table 3).

Toxoplasmosis was estimated to be the most common non-gastroenteritis illness, causing 5,900 new symptomatic illnesses each year, although Australian data were unavailable and this estimate was based on extrapolation from overseas studies.

The proportion of cases transmitted by food for these illnesses ranged from 10% for hepatitis A to 100% for scombrotoxicosis and ciguatera poisoning. These data were taken from cohort studies reported in the literature.

Table 3 **Estimated incidence of acute foodborne illnesses due to 'known' pathogens that do not result in gastroenteritis for one year circa 2000**

Acute illness	Foodborne agents	% foodborne	Foodborne illness
Hepatitis A	Hepatitis A virus	10	150
Invasive listeriosis	*Listeria monocytogenes*	98	120
Toxoplasmosis	*Toxoplasma gondii*	35	5,900
Ciguatera	Ciguatoxin	100	220
Scombrotoxicosis	Histamine compounds	100	280

Incidence of sequelae following foodborne gastroenteritis

KEY FINDINGS

There are about 42,000 incidents of sequelae following gastroenteritis each year.

In Australia each year, contaminated food was estimated to cause about 42,000 episodes of sequelae following acute gastroenteritis (Table 4).

For sequelae following acute foodborne gastroenteritis the most common illness was reactive arthritis, responsible for an estimated 21,000 episodes, while irritable bowel syndrome was responsible for 20,200 episodes each year.

To calculate the number of cases of sequelae following gastroenteritis, both the proportion of the preceding infection that was foodborne and the proportion of

gastroenteritis infections that resulted in sequelae were considered. These data were taken from cohort studies reported in the literature, except for haemolytic uraemic syndrome where Australian foodborne disease experts estimated the proportion due to food as 50%.

Table 4 **Estimated incidence of sequelae following foodborne gastroenteritis for one year circa 2000**

Sequelae	Foodborne agents	% foodborne	Foodborne illness
Haemolytic uraemic syndrome	Shiga toxin producing *E. coli*	50	20
Reactive arthritis	*Salmonella*, *Campylobacter*, *Yersinia*	30	21,000
Irritable bowel syndrome	*Salmonella*, *Campylobacter*, *Shigella*	30	20,200
Guillain-Barré syndrome	*Campylobacter*	20	120

Severe foodborne illnesses: hospitalisations and deaths

KEY FINDINGS

Contaminated food causes an estimated 15,000 hospitalisations due to gastroenteritis, 170 due to other acute illnesses and 2,900 due to sequelae following gastroenteritis.

An estimated 80 people die each year from foodborne gastroenteritis and 45 people die due to other foodborne illnesses.

Hospitalisations

There was an average of 37,008 hospitalisations with a principal or additional diagnosis of gastroenteritis during the period 1993–94 to 1998–99. Of these, an average of 27,225 hospital separations had a principal diagnosis of gastroenteritis. Some hospital separations had multiple diagnoses of a gastroenteritis infection, and there were 41,037 diagnoses for 37,008 separations.

The causative organism was known for 25% of diagnoses (Table 5). The majority of separations were coded as 'gastroenteritis, presumed infectious'. Foodborne transmission was estimated to account for 36% of all 'known' diagnoses of people in hospital with gastroenteritis (see Appendix 6). Overall, approximately 15,000 diagnoses of infectious gastroenteritis were estimated to occur each year due to contaminated food. Foodborne transmission accounted for 70% of admissions for bacterial gastroenteritis, 6% of parasitic infections and 2% of viral infections.

Overall, there were an estimated 170 admissions for acute foodborne illnesses other than gastroenteritis, and an estimated 2,900 admissions for sequelae of foodborne

gastroenteritis (Table 6). The number of admissions was estimated from a variety of sources. The National Hospital Morbidity Database was examined for principal diagnosis only for the period 1999–2000 to 2002–03, so would be expected to underestimate the number of admissions.

For listeriosis, there were an estimated 120 cases, most of which would be expected to be hospitalised. The National Hospital Morbidity Database only recorded an average of 31 cases per year as the principal diagnosis, which is likely to be a significant underestimate. There were no hospitalisations recorded for ciguatera in the Morbidity Database, but Queensland surveillance data showed that there was an average of 7 cases per year. The number of hospitalisations for hepatitis A was similar to prospective hospitalisation rates from cases reported to surveillance. The majority of admissions for sequelae of foodborne gastroenteritis were due to new and ongoing cases of irritable bowel syndrome.

Deaths

There were 1,302 deaths in people in hospital with a diagnosis of infectious gastroenteritis in the six-year period 1993–94 to 1998–99. The mean yearly incidence of deaths due to gastroenteritis was 217, and ranged from 157 to 311 per year. The assumption that 36% of all hospital deaths from infectious gastroenteritis may be due to foodborne transmission gives an estimate of 80 deaths per year (95% CrI: 50–100). These estimates are for deaths where gastroenteritis was likely to have been a contributing factor for death, although not necessarily the only or main reason.

There were an estimated 45 deaths each year due to other foodborne illnesses and sequelae of foodborne gastroenteritis. For some illnesses such as listeriosis, registered deaths data were under-reported compared to case fatality rates from surveillance data. Deaths due to Guillain-Barré syndrome were estimated from cohort studies overseas, where 10% of cases died (Hahn 1998; Kuwabara 2004). This resulted in an estimate of 12 deaths per year, which was more than the average of 4 deaths per year on the registered deaths dataset. Ciguatera was not recorded on the registered deaths dataset, but Queensland surveillance data recorded 1 death over a three-year period.

Table 5 **Estimated hospital separations for gastroenteritis due to foodborne transmission for one year circa 2000**

Microbiological agent	ICD-9-CM code	% foodborne	Foodborne hospitalisations
Bacteria			
Bacillus cereus	008.59	100	29
Campylobacter	008.43	75	2,260
Clostridium perfringens	005.2	100	1
E. coli	008.00–04	50	50
Non-typhoidal *Salmonella*	003	87	1,060
Shigella	004	10	19
Staphylococcus aureus	005.0	100	21
Vibrio parahaemolyticus	005.4	71	3
Yersinia enterocolitica	008.44	75	25
Viruses			
Astro/adenoviruses	008.62/008.66	10	19
Noroviruses	008.63	25	4
Rotaviruses	008.61	2	70
Parasites			
Cryptosporidium	007.4	10	14
Giardia lamblia	007.1	5	49
Unknown			
Unknown aetiology	Various	36	11,000
Total		**36 (95% CrI: 30–41)**	**15,000 (95% CrI: 11,400–18,000)**

Table 6 **Estimated yearly hospital separations and deaths from selected illness due to foodborne agents for one year circa 2000**

Illness	Agent	% foodborne	Foodborne hospitalisations	Foodborne deaths
Acute illnesses				
Hepatitis A[a]	Hepatitis A virus	10	24	1
Invasive listeriosis[a]	*Listeria monocytogenes*	98	120	26
Toxoplasmosis	*Toxoplasma gondii*	35	20	0
Ciguatera	Ciguatoxin	100	7	0
Scombrotoxicosis	Histamine compounds	100	0	0
Sequelae				
Haemolytic uraemic syndrome	Shiga toxin producing *E. coli*	50	30[b]	3
Reactive arthritis	*Salmonella*, *Campylobacter*, *Yersinia*	30	20	0
Irritable bowel syndrome[c]	*Salmonella, Campylobacter*, *Shigella*	30	2,700	3
Guillain-Barré syndrome	*Campylobacter*	20	120	12
Total			**3,000 (95% CrI: 900–5,300)**	**45 (95% CrI: 31–60)**

(a) Invasive listeriosis and hepatitis A cases were adjusted for probable under-reporting.

(b) Some cases were admitted more than once due to hospital transfers.

(c) Irritable bowel syndrome estimates include new and old cases of irritable bowel syndrome each year.

Conclusion and implications

On average, Australians experience an episode of foodborne gastroenteritis every three to four years. It is important to recognise that the assessment of foodborne illness is a process of estimation. A simulation technique was used to indicate uncertainty in the data sources to provide a range of possible values rather than a single figure. Even the most conservative interpretation of the results at the lowest end of the credible interval shows that foodborne illness is a significant public health problem in Australia. While generally not serious, foodborne illness imposes a substantial cost on society in the number of days of work lost and direct medical costs. These effects alone could cost Australia several hundred million dollars each year (Abelson forthcoming).

The National Gastroenteritis Survey highlighted the significant effects of gastroenteritis regardless of the source of infection. Of note, there were over 4.7 million visits to a health facility and 900,000 courses of antibiotics prescribed for gastroenteritis each year. Non-foodborne routes of transmission routes were responsible for 68% of infectious gastroenteritis, equating to 11.7 million cases each year. The majority of these infections were spread from person to person, particularly with common agents such as norovirus, rotavirus, *Giardia lamblia* and pathogenic *E. coli*. Every year, hundreds of outbreaks of viral illness spread from person to person occur in institutions such as nursing homes and hospitals (OzFoodNet Working Group 2003). While person-to-person transmission was not the focus of this assessment, the huge burden of infections highlights the need for further investigation of control measures.

Several groups were affected more commonly with gastroenteritis, including young children and adult carers. The behaviour of young children may increase their exposure to pathogens through both person-to-person and environmental transmission (de Wit et al. 2003; Kapperud et al. 2003; Srikantiah et al. 2004). These infections may be passed on to their predominantly female carers, as shown in the survey. Interestingly, people on higher incomes were at an increased risk of gastroenteritis. This is similar to findings in the United States, and may relate to a greater tendency to report symptoms or to more risky eating patterns (Herikstad et al. 2002).

Indigenous Australians were more likely to experience gastroenteritis, although the difference was not statistically significant due to small numbers. Both Indigenous and non-Indigenous persons were more likely to report gastroenteritis in the Northern Territory than in other states. This highlights the potential importance of climate, along with other environmental and social factors, in the epidemiology of these illnesses (Hall et al. 2002; D'Souza et al. 2004).

The National Gastroenteritis Survey confirmed that only one out of every twenty people with gastroenteritis provided a faecal specimen for testing. This equates to about 500,000 tests each year, which correlates well with data collected by the Health Insurance Commission. Calculating the proportion of people with gastroenteritis who provided specimens allowed the extrapolation from infections reported to health departments to infections occurring in the community.

The National Gastroenteritis Survey estimate of gastroenteritis incidence was similar to that for the Water Quality Study and other Australian surveys (Australian Bureau of Statistics 1991, 1997; Hellard et al. 2001; Gregory & Prasopa-Plaizier 2002; Stafford 2002). The Water Quality Study collected detailed information on pathogens causing gastroenteritis, which was used to assess the aetiological agents responsible for gastroenteritis (Hellard et al. 2001; Sinclair et al. 2001). The incidence of infectious gastroenteritis in Australia is remarkably similar to that reported for the United States (Herikstad et al. 2002; Imhoff et al. 2004) and Canada (Majowicz et al. 2004), but higher than in the United Kingdom (Wheeler et al. 1999), the Netherlands (de Wit et al. 2001) and Ireland (Scallan et al. 2004). These international differences may relate to the methods of study, or even study respondents' willingness to report gastroenteritis in some countries. The estimate of the incidence of gastroenteritis is crucial for estimating the incidence of foodborne illness but differing definitions of gastroenteritis and methods of collecting data make comparisons problematic.

In Australia, 32% of community gastroenteritis and 36% of hospitalised cases of gastroenteritis were estimated to be due to foodborne transmission. This was based on estimation methods developed in the United States by Mead et al. but used Australian data with an added assessment of uncertainty. Mead et al. (1999) estimated that 36% of all illness in the United States was due to contaminated food compared with 26% in the United Kingdom (Adak et al. 2002).

In all three countries, norovirus was one of the most common 'known' pathogens responsible for gastroenteritis. The Australian estimate that 25% of norovirus infections were foodborne compares with 11% for the United Kingdom and 40% for the United States (Mead et al. 1999; Adak et al. 2002). In the United Kingdom and Australia, pathogenic *E. coli* was estimated to cause as much illness as norovirus. The Australian estimate for pathogenic *E. coli* relied on preliminary data from the Water Quality Study; however, recent findings indicate that the burden of disease due to atypical enteropathogenic *E. coli* may be even higher (Robins-Browne et al. 2004). The estimated incidence of enteropathogenic *E. coli* was high in both Australia and the United Kingdom, but the proportion of these illnesses estimated as foodborne varied from 50% to 8% respectively.

Australian society also experiences a significant burden of foodborne illnesses other than gastroenteritis. One example is irritable bowel syndrome, which resulted in approximately 2,700 hospitalisations each year, although it is likely that these were predominantly patients admitted to hospital to exclude diagnoses of malignancies and other disorders. As well as the recognised syndromes considered here, international research shows that common foodborne infections may result in significant premature mortality (Helms et al. 2003). In this report, data were sourced from registered deaths and hospitalisation datasets, which are likely to under-estimate the true incidence of deaths due to foodborne illness (Frenzen 2003, 2004).

This study represents the most considered assessment of the incidence of foodborne illness in Australia. The approach took into account criticisms of earlier estimates (Australia New Zealand Food Authority 1999; Sumner et al. 2000). In future, the assumptions used here will no doubt be revised in light of new knowledge and data.

Some of the key areas where further information is needed to improve understanding of foodborne illness are shown below.

The National Gastroenteritis Survey and assessment of foodborne illness are the first in a series of studies that will provide an increasingly robust picture of the burden of foodborne illness in Australia. Over time, the ongoing studies will be able to monitor change and map this against policy interventions such as new food safety standards and public education campaigns. These estimates will need to be complemented by data from outbreak investigations and case-control studies (O'Brien et al. 2002; Kimura et al. 2004). Such data are important for determining both the nature of the food safety lapses that are responsible for illness, and informing the management of food safety in Australia.

IMPROVING ESTIMATES OF FOODBORNE ILLNESS

Incidence of gastroenteritis It may be useful to internationally standardise the measurement and definition of self-reported gastroenteritis.

Foodborne pathogens To improve the control of foodborne illness, it is important to gain a better understanding of those pathogens that cause the greatest burden. These include foodborne agents, such as pathogenic *E. coli*, norovirus, *Campylobacter* and non-typhoidal *Salmonella*.

Other foodborne illnesses It would be useful to refine the methods of assessing the incidence in Australia for foodborne illnesses that do not result in gastroenteritis.

Hospitalisations and deaths It is important to gather more reliable estimates of hospitalisations and deaths due to gastrointestinal and foodborne pathogens.

Sequelae following acute gastroenteritis Studies to improve knowledge about the incidence and causes of sequelae following gastroenteritis would be useful for assessing the burden on the Australian community.

Appendix 1 **Major foodborne illnesses: key features and data sources**

Information regarding pathogens resulting in gastroenteritis included in the assessment were drawn from a wide range of sources that are detailed in Appendix 2. The study considered 23 different illnesses that may be contracted from contaminated food, four of which were sequelae to gastrointestinal infections. Key features and specific data sources for these illnesses are shown in Table 7.

There were several pathogens which were not considered to cause foodborne illness or were not commonly reported in Australia, including:

- *Clostridium difficile*, which is not thought to be foodborne
- *Clostridium botulinum*, which only causes botulism in infants in Australia and is not thought to be foodborne
- *Salmonella* Typhi, *Vibrio vulnificus*, toxigenic *Vibrio cholerae*, *Entamoeba histolytica*, *Cyclospora cayetanensis*, hepatitis E, *Angylostrongylus cantonensis*, *Brucella*, *Fasciola hepatica*, *Hymenolepis*, *Mycobacterium bovis*, *Taenia*, *Toxocara* and *Trichinella*. Many of these infections occasionally occur in Australian residents but are rare, or are only reported in travellers returning from overseas.

Table 7 **Key features of infections, syndromes and sequelae of acute gastroenteritis assessed, along with primary data sources used**

Pathogen or syndrome	Incubation period	Notifiable in Australia	Major symptoms	Data source[(a)]	Comments
Gastroenteritis					
Aeromonas	Unknown	No	Diarrhoea, abdominal pain	L	Causes gastrointestinal and extra-intestinal infection. Routes of transmission unclear and very little information on this infection. Often affects immunocompromised people. The assessment of incidence was based on South Australian laboratory data.
Bacillus cereus	1–24 hours	No	Nausea, vomiting, diarrhoea	Ob	Illness is due to a heat-stable toxin produced by the bacteria. Acute onset of symptoms that are usually short in duration.
Campylobacter	2–10 days	Yes, except New South Wales	Diarrhoea, nausea, vomiting, abdominal pain, fever	N	Most common cause of gastroenteritis reported to health departments, although rarely recognised as cause of outbreaks. A small proportion of infections result in sequelae of reactive arthritis, irritable bowel or Guillain-Barré syndrome.
Clostridium perfringens	6–24 hours	No	Diarrhoea, nausea	Ob	Illness is due to a heat-stable toxin produced by the bacteria. Acute onset of symptoms is usually short in duration.

continued

Pathogen or syndrome	Incubation period	Notifiable in Australia	Major symptoms	Data source[a]	Comments
Shiga toxin producing *E. coli*	3–8 days	Yes	Bloody diarrhoea, nausea, abdominal pain, fever	S	Organism produces toxin that may result in haemolytic uraemic syndrome. Bloody diarrhoea is a common symptom. Surveillance is usually confined to common serotypes or strains, resulting in non-representative national surveillance data. Data from South Australia used in the assessment.
Pathogenic *E. coli*	9–12 hours	No	Diarrhoea, fever	W	Illness mainly affects infants. Not specifically notifiable in Australia.
Salmonella enterica	6–72 hours	Yes	Diarrhoea, nausea, vomiting, abdominal pain, fever, headache	N	Common illness and cause of outbreaks reported to health departments. A small proportion of infections result in sequelae of reactive arthritis or irritable bowel syndrome.
Shigella	12–96 hours	Yes	Bloody diarrhoea, nausea, abdominal pain, fever	N	An illness related to hygiene often spread from person to person. Bloody diarrhoea is a common symptom.
Staphylococcus aureus	1–8 hours	No	Diarrhoea, vomiting, nausea, abdominal pain	Ob	Illness is due to a heat-stable toxin produced by the bacteria. Violent onset of symptoms and short duration of illness.
Vibrio parahaemolyticus	12–24 hours	No	Diarrhoea, nausea, vomiting, fever, headache	S	Associated with consumption of seafood. Rarely occurs in Australia.
Yersinia enterocolitica	3–7 days	Not all states	Diarrhoea, abdominal pain, fever	N	Pain mimics appendicitis. Significant decline in incidence throughout developed world. No longer notifiable in all Australian jurisdictions.
Astro/ adenoviruses	12–48 hours	No	Diarrhoea, nausea, vomiting, abdominal pain, fever, headache	W	
Noroviruses	10–50 hours	No	Diarrhoea, nausea, vomiting, abdominal pain, fever, headache	W	Often spread person to person. Common cause of point source outbreaks due to highly infectious nature.

continued

Table 7 continued **Key features of infections, syndromes and sequelae of acute gastroenteritis assessed, along with primary data sources used**

Pathogen or syndrome	Incubation period	Notifiable in Australia	Major symptoms	Data source[(a)]	Comments
Rotaviruses	24–72 hours	No	Watery diarrhoea, vomiting, fever	W	Important cause of gastroenteritis in infants and young children.
Cryptosporidium parvum	1–12 days	Yes	Diarrhoea, abdominal pain	W	Mild and asymptomatic infections common. Commonly spread from infected persons and animals, and contaminated water.
Giardia lamblia	3–25 days	Not all states	Diarrhoea, greasy stools, abdominal discomfort, flatulence	W	Difficult to recognise due to the non-specific nature of symptoms and high proportion of asymptomatic infections.
Other foodborne illnesses					
Hepatitis A	15–50 days	Yes	Fever, nausea, abdominal discomfort, lethargy, jaundice	N	Mild or asymptomatic illnesses due to hepatitis A are common in children and may not be recognised. Adults tend to be more seriously affected. Illness usually lasts for about 3 weeks. The clinical spectrum is from little or no symptoms through to very severe illness. The illness is spread via the faecal-oral route, which can involve food contamination, especially where food handlers are infected. However, the predominant route of infection in Australia would be from person to person. Many cases would not present to a doctor and the number of notifications was doubled to account for under-reporting.
Invasive *Listeria monocytogenes*	3–70 days	Yes	Headache, nausea, vomiting, fever, meningitis, abortion, septicaemia	N, O	Listeriosis causes meningitis or septicaemia in immunocompromised individuals and unborn foetuses. For listeriosis there is a significant danger to the unborn foetus if the mother is infected, even if the mother is not very unwell. Each materno-foetal pair is counted as one illness. *Listeria monocytogenes* also causes meningitis or septicaemia in people with weakened immune systems, such as those undergoing chemotherapy. *Listeria* may also cause gastroenteritis, although this is probably under-recognised.

continued

Pathogen or syndrome	Incubation period	Notifiable in Australia	Major symptoms	Data source[a]	Comments
Toxoplasma gondii	10–23 days	No	Fever, infected organs, ocular damage, neurological lesions	O	Toxoplasmosis is a common infection, but the majority of people do not exhibit symptoms. Cats are the definitive hosts of this parasite, and infected cat faeces or ingestion of raw infected meat or water spreads illness. Symptomatic illness affects people who are immunocompromised. Can also infect the unborn foetus leading to foetal abnormalities. Poor data in Australia on incidence. Australian estimates based on data from the United States (Mead et al. 1999).
Ciguatera	1–24 hours	Not all states	Diarrhoea, vomiting, abdominal pain, headache, temperature reversal, neurological symptoms, cardiac arrhythmia	S, Ob	Ciguatera results from the bioaccumulation of algal toxins in the food chain on affected coral reefs. Illness occurs when large tropical or subtropical reef fish are eaten. In Australia, this illness primarily occurs in Queensland. Hospitalisation and case fatality rates taken from outbreak information. Information on the incidence of ciguatera was collected from Queensland. Many milder cases of ciguatera intoxication are not reported, and the under-reporting factor was assumed to be five cases for every case notified.
Scombrotoxicosis	1–6 hours	No	Nausea, vomiting, headache, rash, tingling around mouth	Ob	Scombrotoxicosis or histamine poisoning is associated with build-up of histamine in fish that have been poorly handled during processing. Outbreaks of histamine poisoning occur throughout Australia, although it is not commonly reported. To assess the incidence of this illness, outbreak data were used, allowing for cases not recognised as part of an outbreak.
Sequelae					
Reactive arthritis (ReA)	2 weeks following infection	No	Arthritis	O	ReA is a non-purulent joint inflammation that may be triggered by gut or urethral infections. Enteric infections with *Salmonella*, *Yersinia* and *Campylobacter* are recognised antecedent causes of ReA. Symptoms of swelling and pain of joints occur within the first weeks after a gastrointestinal infection. Some people may have a genetic predisposition to develop ReA. The arthritis is fairly mild in most cases; severity ranges from mild to severe. The illness lasts weeks to months and is most common in middle-age. The incidence of ReA was derived by applying the relevant proportions of cases found in the overseas studies to the estimate of the total number of gastroenteritis cases caused by certain bacterial pathogens in Australia.

continued

Table 7 continued **Key features of infections, syndromes and sequelae of acute gastroenteritis assessed, along with primary data sources used**

Pathogen or syndrome	Incubation period	Notifiable in Australia	Major symptoms	Data source[(a)]	Comments
Haemolytic uraemic syndrome (HUS)	5-day prodrome of diarrhoea	Yes	Acute renal failure, haemolytic uraemia and other blood disorders	N	HUS may be caused by renal insult from toxins produced by foodborne bacteria, such as *E. coli* and *Shigella dysenteriae*. HUS may follow a prodrome of acute gastroenteritis. There are also other non-enteric causes of HUS. Children under five years of age are more vulnerable to serious illness than adults. There have been large outbreaks of HUS in Australia due to contaminated food (Cameron et al. 1995). Data for the assessment were collected from the National Notifiable Diseases Surveillance System.
Irritable bowel syndrome (IBS)	Post-infection	No	Diarrhoea, abdominal discomfort, irregular bowel movements, constipation	H	IBS may last from several days to many months. The bowel is thought to be oversensitive, which may be lifelong. Stress, diet or infection can trigger IBS. About 7% of enteric infections with *Campylobacter, Salmonella* and *Yersinia* result in IBS. The incidence of IBS was derived by applying the relevant proportions of cases found in the overseas studies to the estimate of the total number of gastroenteritis cases caused by certain bacterial pathogens in Australia.
Guillain-Barré syndrome	Post-infection	No	Weakness in extremities, respiratory paralysis	H	An autoimmune illness affecting the nervous system. Different triggers may cause Guillain-Barré syndrome, but *Campylobacter* infections are estimated to cause approximately 20% of cases. The illness is more common in older people. Illness lasts from a few weeks to months, but in 20% of cases residual weakness is lifelong. Approximately 8% of those affected die. The estimate of the incidence of Guillain-Barré syndrome was based on the assumption that all cases would be admitted to hospital. Data from the National Hospital Morbidity Database gave the estimate of all cases of Guillain-Barré syndrome in Australia each year.

(a) Primary data sources used in estimation: N = National Notifiable Diseases Surveillance System; S = State surveillance data; W = Water Quality Study; L = Laboratory data; H = Hospitalisation dataset; Ob = Outbreak data; O = Other.

Appendix 2 **Australian datasets to assess foodborne illness**

Information regarding pathogens resulting in foodborne illness was drawn from a wide range of sources, including national datasets on infectious illnesses and specific research studies. These various data were used to estimate national totals of human infections occurring in Australia each year for each pathogen. A basic description for the different data sources used in the study and the specific information used for the assessment are listed below.

State and territory infectious illness surveillance

Legislation in all Australian jurisdictions requires doctors and pathology laboratories to report diagnoses of patients with certain infections to a state or regional health department. Health department staff enter basic information such as the patient's age, sex and address, and infecting organism into a database. The data in these databases are used to identify outbreaks and trends in infectious illnesses.

Each jurisdiction has over 50 different illnesses under surveillance, many of which are not foodborne in nature. The specific illnesses that are reportable vary slightly from jurisdiction to jurisdiction, particularly where certain illnesses have differing regional distribution, such as ciguatera poisoning that is notifiable only in Queensland. However, data elements and case definitions for many illnesses are largely standardised across Australia.

Health departments also receive reports of outbreaks of foodborne illnesses from doctors, laboratories, local government and members of the public. Often these are a common event where many people have eaten together and subsequently become ill. These outbreaks are investigated to determine the cause, and interventions are carried out where appropriate. The microbiological agents responsible for these outbreaks are often not specifically notifiable to health departments, except in outbreak settings.

The specific information used in assessing the burden of foodborne illness from state and territory surveillance was:

- numbers of infections or foodborne syndromes where illnesses were not nationally notifiable
- proportion of infections acquired from overseas travel.

National Notifiable Disease Surveillance System

The National Notifiable Diseases Surveillance System (NNDSS) was established in 1990 under the auspices of the Communicable Diseases Network Australia. The NNDSS is managed by the Australian Government Department of Health and Ageing and aggregates de-identified surveillance data from state and territory health

departments. More than 50 communicable diseases or disease groups are included. The database is used for monitoring national trends in the notification of various diseases. Data elements include basic details of a patient's age, sex, date of illness, postcode of residence and infecting organism. For further information on the operation of the NNDSS see <http://www.cda.gov.au/surveil/index.htm>.

The specific information used in assessing the burden of foodborne illness from the NNDSS was:

- national numbers of infections or syndromes potentially due to food.

OzFoodNet

OzFoodNet, established by the Australian Government in 2000, is a national network of epidemiologists who work within state and territory health departments to enhance national surveillance of foodborne illnesses. The main role of OzFoodNet is to determine the burden and causes of foodborne illness and to coordinate national investigations of foodborne illness. One of the main projects to determine the burden of infection was the National Gastroenteritis Survey, which was coordinated by the National Centre for Epidemiology and Population Health.

OzFoodNet epidemiologists also collect enhanced surveillance data on a variety of foodborne illnesses and outbreaks, which are aggregated nationally. The aggregation of outbreak information regarding gastrointestinal and foodborne illness is important for the development of policy, as many illnesses are not specifically notifiable. For further information on the OzFoodNet program of work see <www.ozfoodnet.org.au>.

The specific information used in assessing the burden of foodborne illness from OzFoodNet was:

- information arising from the National Gastroenteritis Survey on gastroenteritis incidence and factors relating to under-reporting of illness
- proportion of infections or intoxications that were foodborne from summaries of outbreak information
- under-reporting factors from summaries of outbreak information and case control studies.

National Hospital Morbidity Database

The Australian Institute of Health and Welfare administers the National Hospital Morbidity Database (NHMD). The NHMD is a compilation of inpatient hospital data supplied by state and territory health authorities. The data relate to individual patient admissions to public and private hospitals. Data are categorised according to the ICD versions 9 and 10 depending on jurisdiction and year. Each record contains information on dates of encounter and stay, patient characteristics, reason for admission, specific diagnoses, and cause of death where relevant. For further

information regarding the NHMD see <http://www.aihw.gov.au/hospitaldata/morbidity.html>.

The specific information used in assessing the burden of foodborne illness from the NHMD was:

- specific numbers of hospitalisation and death due to gastrointestinal infectious agents or foodborne syndromes.

Water Quality Study

The Cooperative Research Centre for Water Quality and Treatment conducted the Water Quality Study between 1997 and 1999. The Water Quality Study was a randomised–controlled trial to examine the relationship between water quality and gastroenteritis in the city of Melbourne. The study was conducted in southeastern suburbs of Melbourne. Six hundred families were randomly allocated to receive a real or sham water treatment unit. Each family recorded details of gastroenteritis, medical treatment, travel, recreational water activities and other relevant information in weekly health diaries. Adult participants provided blood samples for serological testing, and both adults and children provided faecal specimens for pathogen analysis at baseline and following episodes of gastroenteritis. For further information on the Water Quality Study see <http://www.med.monash.edu.au/epidemiology/infdis/waterqstudy.html>.

The specific information used in assessing the burden of foodborne illness from the Water Quality Study was:

- the proportion of infectious agents causing diarrhoea in community gastroenteritis
- the incidence of respiratory symptoms that occur concurrently with gastrointestinal symptoms.

Registered deaths data

Death certificates are sent to the Registrars of Births, Deaths and Marriages in each state and territory. Registration of deaths is the responsibility of individual state and territory registrars and is based on the data provided on an information form. This information is provided to the Australian Bureau of Statistics for processing and production of death statistics. The Australian Institute of Health and Welfare also holds a copy of the dataset. The data cover all deaths registered in Australia and detail age at death, sex, Indigenous status, country of birth, duration of residence, month of occurrence, month of registration, occupation, usual residence of deceased, place of death and cause of death. The causes of death are classified according to the 9th (1979–98) revision of the ICD for data files from 1964 to 1998, and the 10th revision for 1999 onwards. For further information on the registered deaths data see <http://www.aihw.gov.au/mortality/data/collection_data.html>.

The specific information used in assessing the burden of foodborne illness from the registered deaths data was:

– deaths due to illnesses potentially transmitted by food.

Other sources of information

The assessment of foodborne illness also relied on data from laboratory surveys, published reports in the literature and discussions with physicians and foodborne disease experts. For more information on the specific data sources and methods used in this report see < http://nceph.anu.edu.au/Publications/working_papers.php > .

Appendix 3 Under-reporting to surveillance

Many cases of infectious gastroenteritis and foodborne illness under surveillance by health departments are not detected for several reasons. Only small proportions of people infected with enteric pathogens seek treatment and subsequently submit specimens for testing. An even smaller proportion of people test positive for a pathogen that doctors and laboratories notify to the health department.

The amount of illness actually occurring in the community that is reported to the health department varies by infectious agent and relates to the severity and duration of illness. To estimate these proportions, pathogens were classified as causing 'moderate illness' or 'serious illness' or if they resulted in 'bloody diarrhoea'. Some pathogens cause outbreaks and are not reported to surveillance systems as individual cases and were adjusted using an 'outbreak factor'. The under-reporting factor for each of these categories was estimated using information from different data sources, which are summarised below.

Moderate illness

The under-reporting factor for moderate illness was 15, with a credible interval of 5–25, that is, 15 unreported illnesses are estimated to occur in the community for every reported illness.

This estimate was derived by comparing information from the following sources:

- **Outbreak investigations of salmonellosis in Victoria** For every 6 cases of *Salmonella* that occurred during an outbreak, about 1 case was reported.
- **Melbourne Water Quality Study** (Hellard et al. 2001) Approximate under-reporting factors for salmonellosis and campylobacteriosis were 23 and 21 respectively. This was calculated by dividing the number of infections in people participating in the study, and by the number of cases reported to the health department in the specific study area.
- **National Gastroenteritis Survey** An under-reporting factor of 11 was estimated using duration of illness, visits to a medical practitioner and stool sampling. This was combined with duration of salmonellosis from a case-control study in the Hunter region of New South Wales (Yohannes 2002).

Bloody diarrhoea

The under-reporting factor for bloody diarrhoea was 9, with a credible interval of 1–17, as 9 unreported illnesses are estimated to occur in the community for every reported illness.

This was derived from the National Gastroenteritis Survey. In the survey 12 people had bloody diarrhoea, 3 of whom saw a general practitioner; 2 had a stool specimen taken. This means that 17% (95% CI: 7–32%) of people with blood in their stools

have a stool test, equating to 1 person having a stool test for every 3–14 instances of bloody diarrhoea in the community. The numbers are small, but are similar to those in larger studies in the United States (Voetsch et al. 2004). The under-reporting factor was adjusted to take into account uncertainty about the sensitivity of the laboratory test and reporting.

Serious illness

The under-reporting factor for serious illness was estimated as 1 reported illness for every 2 illnesses that occur in the community, with a credible interval of 1–3. This was the same factor used in the study by Mead et al. (1999).

Outbreak-related data

The under-reporting factor for outbreak-reported illness compared to reported cases was 14, with a credible interval of 6–22. The outbreak factor was used to adjust data for illnesses that are only reported in outbreak settings, such as *Bacillus cereus* intoxication. These pathogens are not reported to surveillance systems as individual cases. The factor was estimated from Victorian outbreak data based on the ratio of *Salmonella* infections diagnosed during outbreak investigations compared to those reported to surveillance systems.

Appendix 4 **Estimating the proportion of illness due to food**

Determining the amount of illness that was likely to be acquired from contaminated food was based on an examination of illness caused by 'known' pathogens and syndromes. Data to inform this process came from summaries of outbreaks, literature reviews and collation of opinions from foodborne disease experts in Australia. Estimates for the proportion of sequelae due to foodborne causes were based on information in the literature and opinions from specialist physicians.

For each of the 16 pathogens that were assessed as causing gastroenteritis, a literature survey was used to identify sources for estimating the proportion of transmission likely to be due to food. Data on transmission modes was particularly scant, and the literature review was supplemented by opinion from a Delphi process.

Data from Victorian outbreaks, covering all possible modes of transmission, were used to inform this process. The proportion of outbreaks and number of cases due to food, for each pathogen, was summarised and the information distributed to ten Australian epidemiologists and public health physicians experienced in foodborne illnesses. These experts discussed the results to gain consensus about the proportion of illness for each pathogen that may be attributed to food.

There are little data on what proportions of haemolytic uraemic syndrome, invasive *Listeria*, toxoplasmosis and hepatitis A illnesses are due to foodborne transmission. Eight foodborne disease experts were asked to estimate the proportion due to foodborne transmission in May 2004. Supplementary data for this process were obtained from the Australian Paediatric Surveillance Unit (2001) and the Victorian surveillance system (Joy Gregory, pers. comm., May 2004).

Appendix 5 **National Gastroenteritis Survey**

During the 12 months of the study, the response rate[5] for the survey was 67% (6,087/9,065). The lowest response rate was 62% for Victoria and the highest was 74% in Tasmania. There were a total of 6,087 interviews conducted compared to a target for the survey of 6,234 households.

A total of 683 respondents reported they had experienced 'diarrhoea or vomiting' in the previous four weeks, equating to 26 million episodes of vomiting or diarrhoea each year in Australia (Table 8). Respiratory symptoms were very commonly reported, with 29% of those people reporting any diarrhoea or vomiting also reporting symptoms of sore throat, runny nose, sneezing or cough. The primary definition of gastroenteritis was met by 450 respondents, which equates to 17.2 million cases of gastroenteritis in Australia in 2001–02.

Table 8 **Number and incidence of vomiting or diarrhoea and gastroenteritis in Australia, National Gastroenteritis Survey, 2001–02**

Definition	Millions of episodes per year (95% CI)	Episodes per person per year (95% CI)
Any diarrhoea or vomiting	25.9 (23.3–28.7)	1.4 (1.2–1.5)
Gastroenteritis[(a)]	17.2 (14.5–19.9)	0.9 (0.8–1.1)

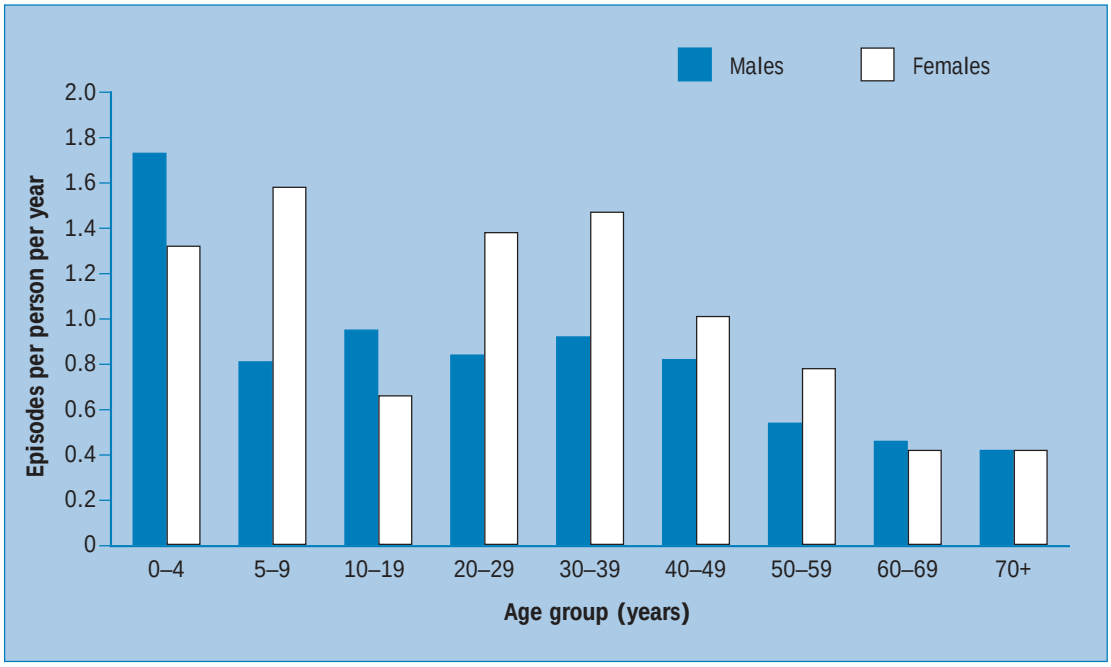
(a) See definition of gastroenteritis on page 43.

Children under 5 years old and women between 20 and 40 years old reported the most gastroenteritis (Figure 3). People over 60 years old were least likely to report gastroenteritis. Teenagers also reported less gastroenteritis. Females were 30% more likely to report gastroenteritis than males, particularly in the 5–9 and 20–40 years age groups. Examination of the data showed that women in the 20–40 years age group who reported gastroenteritis were also more likely to have children less than 5 years old with gastroenteritis in their household.

The Northern Territory had the highest incidence of gastroenteritis at 1.3 cases per person per year (Table 9). Both Indigenous and non-Indigenous respondents from the Northern Territory reported high levels of gastroenteritis. Despite this, Indigenous respondents had a rate double that of the non-Indigenous population, although the difference was not statistically significant due to small numbers. The incidence was between 0.9–1.0 episodes per person per year for all other states and territories.

5 The response rate is the proportion of households that were contacted by telephone and took part in the survey, divided by the total number contacted. It is important to have a high response rate to ensure that the survey results are generalisable to the population under study.

Figure 3 **Incidence of gastroenteritis in Australia, by age and sex, National Gastroenteritis Survey, 2001–02**



Gastroenteritis varied between seasons, with the highest levels reported in summer and winter. The incidence of gastroenteritis was lowest in autumn. When the analysis took demographic and other factors into account, the variation across seasons was statistically significant.

People with household incomes greater than $100,000 a year were more likely to report gastroenteritis compared with those with lower incomes. The incidence of gastroenteritis was no different between rural and urban dwellers, except in New South Wales – Australian Capital Territory, where it was higher in rural areas.

The most common symptoms for cases meeting the primary definition of gastroenteritis were diarrhoea (82%), and cramps, nausea and loss of appetite were reported by around 60% of cases (Table 10). Vomiting was present in nearly half the cases. Respiratory tract symptoms were present in about a quarter of cases. Blood in the stool was present in only 2% of cases. Duration of gastroenteritis was defined as the period from the beginning of either vomiting or diarrhoea to the cessation of both of these symptoms. Most illnesses had diarrhoea and/or vomiting lasting one or two days. The median duration was two days and only one-quarter of cases had diarrhoea and/or vomiting lasting over three days.

More than a quarter of respondents who reported gastroenteritis sought treatment at a health facility, some visiting more than one facility (Table 11). This extrapolates to 4.7 million visits to a health facility in Australia each year for gastroenteritis, with 3.8 million of these visits to a medical practitioner.

Table 9 **Gastroenteritis reported by survey respondents in the last four weeks by demographic factors, National Gastroenteritis Survey, 2001–02**

Characteristic	Number of respondents (n=6,087)	Proportion of persons reporting gastroenteritis in previous 4 weeks (%)	95% CI (%)
Sex			
Male	2,757	6.3	4.7–7.8
Female	3,330	7.7	6.1–9.4
Age			
0–4 years	322	11.0	5.2–16.8
5–9 years	286	9.2	4.1–14.3
10–19 years	650	6.2	3.5–8.9
20–29 years	708	8.5	5.5–11.5
30–39 years	872	9.2	6.3–12.2
40–49 years	868	7.0	3.8–10.3
50–59 years	905	5.1	3.0–7.2
60–69 years	686	3.4	1.8–5.0
70+ years	790	3.2	0.8–5.7
State			
Queensland	824	7.0	4.5–9.5
New South Wales – ACT	1,029	6.6	4.7–8.6
Victoria	892	7.3	5.4–9.3
Tasmania	843	6.8	4.8–8.7
South Australia	779	7.2	5.03
Northern Territory	861	9.6	6.3–12.9
Western Australia	859	7.2	4.5–9.9
Season			
Spring	1,774	5.9	4.6–7.3
Summer	1,708	8.4	6.5–10.3
Autumn	1,263	5.9	3.5–8.3
Winter	1,342	7.8	5.3–10.2
Indigenous status			
Indigenous	146	14.9	2.5–27.2
Non-Indigenous	5,935	6.9	5.8–7.9

continued

Characteristic	Number of respondents (n=6,087)	Proportion of persons reporting gastroenteritis in previous 4 weeks (%)	95% CI (%)
Education			
Primary	83	5.9	0.0–12.4
Years 7–10	681	5.1	2.5–7.8
Years 11–12	1,143	7.9	5.6–10.3
Post-school	4,056	7.0	5.8–8.1
Unknown	124	9.3	
Income			
<$25,000 per annum	1,705	7.7	5.5–9.9
$25,000 to <$50,000	1,552	7.6	5.3–9.9
$50,000 to <$100,000	1,613	7.1	5.2–9.1
≥$100,000	545	8.4	4.7–12.2
Unknown	672	4.0	
Health insurance			
Yes	3,159	3.4	0.0–8.5
No	2,865	6.3	4.8–7.7
Unknown	63	8.0	
Locality			
Urban/town	5,017	7.2	5.8–8.6
Rural community/farm	1,064	6.3	4.5–8.1
Household size			
1	1,348	5.2	3.7–6.7
2	1,934	5.6	4.2–7.1
3	985	8.9	6.9–11.0
4	1,122	7.4	4.8–10.1
5	491	9.3	5.8–12.9
6+	207	5.2	2.3–8.2

Table 10 **Symptom profile for people reporting gastroenteritis, National Gastroenteritis Survey, 2001–02 (n=450)**

Symptom	Cases with symptom[(a)] (n=450)	Proportion with symptom (%)	95% CI (%)
Aches	140	31	24–37
Loss of appetite	292	63	54–71
Blood in stool	13	2	1–4
Abdominal cramps	270	60	55–65
Diarrhoea	381	82	78–87
Fever	171	39	31–46
Headache	191	45	37–52
Nausea	254	54	46–62
Stiff neck	63	15	9–20
Upper respiratory tract infection	114	25	18–32
Vomiting	201	46	38–55

(a) Data unweighted.

Table 11 **Number of people reporting gastroenteritis seeking health care, National Gastroenteritis Survey, 2001–02 (n=450)**

Health facility	Proportion visiting (%)[(a)]	Million visits (95% CI)
Visiting at least one health facility	28.4	4.7 (3.3–6.0)
Visiting a medical officer	22.2	3.8 (2.6–4.9)
Pharmacy	8.4	1.2 (0.7–1.8)
Hospital admission	2.7	0.4 (0.1–0.8)
Other	2.9	0.5 (0.0–1.0)

(a) Data unweighted.

Examination of the data showed that people with more severe illness were more likely to visit a medical practitioner. The duration of a person's diarrhoea or vomiting was the strongest predictor of whether they visited a doctor. People experiencing fever and lost appetite were also more likely to visit a doctor. People's demographic features, such as age, sex, Indigenous status and level of income, were less of an influence on whether a doctor was visited.

Of those who had diarrhoea and visited a general practitioner, 22% had a stool test ordered. This equates to 522,360 stool tests submitted in Australia in 2001–02. Duration of diarrhoea strongly predicted whether a stool sample was taken. Fewer than 1% of people submitted a stool specimen if their diarrhoea lasted ≤ 2 days, compared to 9% where diarrhoea lasted 3–4 days and 29% where diarrhoea lasted ≥ 5 days.

About 42% of those reporting gastroenteritis took at least one medication, most commonly for pain relief. This equates to over seven million people taking medication for gastroenteritis each year. About 5% of those who reported gastroenteritis were prescribed an antibiotic, which extrapolates to over 900,000 courses of antibiotics in a single year.

Gastroenteritis resulted in a large number of days of missed work and other activities (Table 12). Extrapolation from the data indicates that about 6.5 million days were lost from paid work each year. About 60% of instances where a person missed paid work were due to the person being ill themselves, while 40% were due to another person having to care for a person with gastroenteritis.

Table 12 **Missed paid work due to gastroenteritis in Australia each year, National Gastroenteritis Survey, 2001–02**

Type of missed paid work	Paid work days missed	Range (95% CI)
Missed paid work themselves	3.8 million	2.5–5.2 million
Other person missed paid work to care for person with gastroenteritis	2.7 million	0.5–4.8 million
Total days of missed paid work	6.5 million	4.0–9.1 million

The survey respondents were similar to the 2001 census conducted by the Australian Bureau of Statistics. Compared to the 2001 census the survey had an under-representation of children and over-representation of older people, as would be expected when the household is randomly selected first, followed by the respondent. This is due to the large number of single-person households where the respondent is necessarily an adult. The weighted proportion of 'education up to year 10' in the survey respondents (41%) was slightly lower than in census subjects (47%).

Appendix 6 **Incidence, hospitalisations and deaths—total and foodborne**

Total and foodborne incidence

Table 13 **Estimated incidence of foodborne gastroenteritis due to 'known' pathogens in Australia for one year circa 2000**

Nature of infection	Microbiological agent	Total cases (95% CrI)	% foodborne (95% CrI)	Foodborne illness (95% CrI)
Bacterial	*Aeromonas*	39,000 (31,700–47,200)	25 (12–38)	9,800 (4,100–15,400)
	Bacillus cereus	6,900 (0–16,000)	100	6,900 (0–15,800)
	Campylobacter	277,000 (89,800–460,000)	75 (67–83)	208,000 (67,000–350,000)
	Clostridium perfringens	43,000 (440–86,000)	100	43,000 (400–86,000)
	Shiga toxin producing *E. coli*	3,000 (0–6,500)	65 (48–82)	1,900 (0–4,200)
	Pathogenic *E. coli*	1,152,000 (797,000–1,507,000)	50 (32–68)	563,000 (295,000–831,000)
	Non-typhoidal *Salmonella*	92,000 (26,000–158,000)	87 (81–93)	81,000 (23,000–138,000)
	Shigella	3,200 (0–6,900)	10 (4–16)	300 (0–700)
	Staphylococcus aureus	14,100 (0–29,800)	100	14,200 (0–29,800)
	Vibrio parahaemolyticus	1,080 (0–2,600)	71 (54–88)	740 (0–1,850)
	Yersinia enterocolitica	2,200 (0–4,500)	75 (63–87)	1,620 (0–3,400)
Viral	Astro/adenoviruses	190,000 (63,000–316,000)	10 (2–18)	17,500 (0–36,800)
	Noroviruses	1,832,000 (1,361,000–2,302,000)	25 (12–38)	446,000 (193,000–700,000)
	Rotaviruses	241,000 (98,000–384,000)	2 (1–3)	4,700 (700–8,600)
Parasitic	*Cryptosporidium*	271,000 (255,000–287,000)	10 (2–18)	25,000 (0–54,000)
	Giardia lamblia	430,000 (232,000–628,000)	5 (1–9)	20,400 (0–41,100)
Total		**4,640,000 (3,750,000–5,510,000)**	**32 (24–40)**	**1,480,000 (1,030,000–1,920,000)**

Table 14 **Estimated total and acute foodborne illnesses due to 'known' pathogens that do not result in gastroenteritis in Australia for one year circa 2000**

Acute illness	Agent	Total cases (95% CrI)	% foodborne (95% CrI)	Foodborne illness (95% CrI)
Hepatitis A	Hepatitis A virus	1,500 (0–6,900)	10 (0–24)	150 (0–1,000)
Invasive listeriosis	*Listeria monocytogenes*	120 (100–200)	98 (92–100)	120 (100–130)
Toxoplasmosis (symptomatic)	*Toxoplasma gondii*	17,100 (9,000–26,000)	35 (0–71)	5,900 (0–13,900)
Ciguatera	Ciguatoxin	220 (0–600))	100	220 (0–780)
Scombrotoxicosis	Histamine compounds	280 (0–1,000)	100	280 (0–1,000)

Table 15 **Estimated sequelae from foodborne gastroenteritis in Australia for one year circa 2000**

Sequelae	Agent	Total cases (95% CrI)	% foodborne (95% CrI)	Foodborne illness (95% CrI)
Haemolytic uraemic syndrome	Shiga toxin producing *E. coli*	30 (0–100)	50 (0–100)	20 (0–40)
Reactive arthritis	*Salmonella, Campylobacter, Yersinia*	67,000 (20,000–136,000)	30 (20–40)	21,000 (6,400–36,000)
Irritable bowel syndrome	*Salmonella, Campylobacter, Shigella*	65,000 (17,500–195,000)	30 (10–60)	20,200 (6,400–35,800)
Guillain-Barré syndrome	*Campylobacter*	650 (540–770)	20 (15–25)	120 (90–160)

Table 16 **Diagnoses of gastroenteritis in hospital separations: total and foodborne cases in Australia for one year circa 2000**

Nature of infection	Microbiological agent	ICD-9-CM code	Total hospital diagnoses (95% CrI)	% foodborne (95% CrI)	Foodborne hospitalisations (95% CrI)
Bacterial	*Bacillus cereus*	008.59	29 (0–66)	100	29 (0–66)
	Campylobacter	008.43	3,140 (1,754–4,546)	75 (67–83)	2,260 (1,250–3,300)
	Clostridium perfringens	005.2	1 (0–3)	100	1 (0–3)
	E. coli unspecified	008.00-04	102 (53–154)	50 (32–68)	50 (23–86)
	Non-typhoidal *Salmonella*	003	1,330 (1,130–1,530)	87 (81–93)	1,060 (900–1,240)
	Shigella	004	320 (270–370)	10 (4–16)	19 (8–31)
	Staphylococcus aureus	005.0	21 (17–25)	100	21 (17–25)
	Vibrio parahaemolyticus	005.4	4 (2–6)	71 (54–88)	3 (1–5)
	Yersinia enterocolitica	008.44	34 (24–44)	75 (63–87)	25 (17–35)
Viral	Astro/adenoviruses	008.62/008.66	190 (130–250)	10 (2–18)	19 (4–37)
	Noroviruses	008.63	17 (2–32)	25 (12–38)	4 (0–9)
	Rotaviruses	008.61	3,740 (3,540–3,920)	2 (1–3)	70 (40–110)
Parasitic	*Cryptosporidium*	007.4	200 (0–400)	10 (2–18)	14 (0–49)
	Giardia lamblia	007.1	1,000 (900–1,100)	5 (1–9)	49 (7–90)
Unknown	Other miscellaneous agents	Various	2,800 (2,400–3,200)	36 (30–41)	1,000 (800–1,200)
	Unknown aetiology	Various	28,000 (20,000–35,700)	36 (30–41)	10,000 (6,800–13,200)
Total			**41,000 (33,000–49,000)**	**36 (30–41)**	**15,000 (11,400–18,000)**

Table 17 **Estimated yearly hospital admissions and deaths from selected illnesses due to foodborne agents in Australia for one year circa 2000**

Illness	ICD-10-AM code	% foodborne (95% CrI)	Foodborne hospitalisations (95% CrI)	Foodborne deaths (95% CrI)
Acute illnesses				
Hepatitis A	B15	10 (0–24)	24 (0–73)	1 (0–1)
Invasive listeriosis	A32.9, P37.2	98 (92–100)	120 (100–130)	26 (12–40)
Toxoplasmosis	B58, P37.1	35 (0–71)	20 (0–50)	0 (0–2)
Ciguatera	T61.0	100	7 (0–19)	0 (0–1)
Sequelae				
Haemolytic uraemic syndrome	D59.3	50 (0–100)	30 (0–80)	3 (0–7)
Reactive arthritis	M02, M03	30 (20–40)	20 (10–30)	0 (0–1)
Irritable bowel syndrome	K58	30 (10–60)	2,700 (700–5,100)	3 (1–6)
Guillain-Barré syndrome	G61.0	20 (15–25)	120 (100–170)	12 (7–17)

Terms used in this report

Burden of disease The burden of disease refers to the mortality, disability, impairment, illness and injury resulting from that particular disease.

Cohort An epidemiological term used to mean any designated group of persons who are followed or traced over a period of time to determine the incidence of illness and compare with previous exposures.

Confidence interval (CI) A statistical term describing a calculated range (interval) with a given probability that the true value of a variable (such as a median or mean) is contained within the interval. Confidence intervals are calculated when a sample is taken from the population. In most instances, 95% confidence intervals are reported, which indicates the range of values for which the probability is 95% that it contains the true population value.

Credible interval (CrI) A concept used where data are scarce. Available data are used to simulate a plausible distribution. The middle 95% of the distribution is the 'credible interval', which describes the uncertainty in the estimates. A 95% credible interval means there is a 95% probability that the true value is contained in the interval. A wider interval indicates a higher level of uncertainty.

Diarrhoea More frequent and loose bowel movements than normal. Diarrhoea may be a symptom of a range of illnesses due to infection, injury, colitis or a gastrointestinal tumour. A common definition of diarrhoea is three or more loose stools in a 24-hour period.

E. coli *Escherichia coli*, bacteria commonly found in the faeces of humans and many animals. Some pathogenic strains cause gastrointestinal infection that may result in illnesses such as haemolytic uraemic syndrome (HUS).

Foodborne illness Foodborne illness includes any human disease of an infectious or toxic nature that is caused by ingestion of food, including food contaminated during growing, harvesting, processing, preparation, washing in contaminated water or by contact with unhygienic surfaces.

Incidence The occurrence of new cases of a given illness in a specified population and time period.

ICD Acronym for International Statistical Classification of Diseases and Related Health Problems developed by the World Health Organization. ICD is the international standard for classifying diseases and other related health problems, such as symptoms or injury. There are several versions of the coding system in use in Australia, mainly versions 9 and 10. Diseases are assigned codes in hierarchical order. 'AM' refers to an Australian modification of the ICD-10 coding set. 'CM' refers to a clinical modification of ICD-9.

Gastroenteritis An infection or irritation of the stomach and intestines. Illness may consist of a variety of symptoms, but commonly includes nausea, vomiting, diarrhoea, abdominal pains and fever. In epidemiological studies gastroenteritis is specifically defined using a group of common symptoms.

Hospital separation A term used in hospital statistics to describe the departure of a patient from hospital. Separations are commonly used to measure the use of hospital services rather than admissions, as a definite diagnosis may only be established during the hospital stay. The terms 'separation', 'discharge', 'hospital discharge/separation', 'stay' and 'admission' are often used interchangeably.

Mode of transmission The mechanism by which a pathogen is passed from an infection source to the person that becomes infected. For example, if a person acquires an infection from patting an animal, the mode of transmission is 'animal-to-person'.

Pathogen A microorganism that causes illness.

Sequelae Illness that occurs as a consequence of acute infection, which may occur some time after the original illness. This may be due to mechanical damage to the bowel, production of a toxin, or an auto-immune response. Sequelae following gastroenteritis may be acute, such as haemolytic uraemic syndrome following infection with Shiga toxin producing *E. coli*, or chronic, such as irritable bowel syndrome following *Salmonella* infection.

Stool Waste food material from the body passing out of the bowel. When a person has gastroenteritis, microbiological testing of stool specimens can identify the pathogen responsible for their illness. 'Faeces' is a common synonym for 'stool'.

Surveillance The process of collecting, collating and analysing data for public health purposes. A key feature of surveillance is that the resulting information must be disseminated in a timely fashion to people or agencies who are in a position to act to prevent illness.

Under-reporting In public health, under-reporting is where cases of infection are not reported to the surveillance system for various reasons. The less severe a person's symptoms, or the more difficult a pathogen is to detect, the greater the degree of under-reporting that can be expected.

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