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Original article

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Abstract

Fresh produce is an important source of foodborne outbreaks in Australia. Using descriptive analysis, we examined confirmed and suspected foodborne outbreaks associated with fresh produce in Australia recorded in the OzFoodNet outbreak register from 2001 to 2017. The outbreak register contains reports of foodborne disease outbreaks collected by OzFoodNet epidemiologists and public health officials. A fresh produce outbreak was defined as the occurrence of two or more cases of the same illness in which the investigation had implicated a common food and this food contained fresh produce. A total of 92 fresh produce outbreaks were reported, encompassing 3,422 reported illnesses, 446 hospitalisations and four deaths. Of these outbreaks, 76.1% (70/92) were caused by a known pathogen, with the majority caused by either *Salmonella enterica* (n = 30) or Norovirus (n = 29). Most outbreaks (77.2%; 71/92) were associated with consumption of foods containing multiple ingredients, some of which were not fresh produce. The largest outbreaks associated with a single fresh produce item included bean sprouts contaminated with *S. enterica* serovar Saintpaul (419 illnesses and 76 hospitalisations) and semi-dried tomatoes contaminated with Hepatitis A (372 illnesses and 169 hospitalisations). Restaurants (45.7%; n = 42/92) and commercial catering (15.2%: n = 14/92) were common settings for fresh produce outbreaks. Outbreaks occurred in all states and territories of Australia and in all seasons, with an increased frequency in the warmer months (September–May). Although the number of fresh produce-associated outbreaks did not seem to be increasing in Australia, integrated surveillance is needed to rapidly identify sources of infection due to the propensity of these outbreaks to be large and widespread.

Keywords: Australia; foodborne disease; fresh produce; Norovirus; outbreaks; Salmonella; sprouts

Introduction

The increasing variety of fresh produce sold worldwide, together with an industrialised production process, has resulted in a rise in the frequency of produce-linked disease outbreaks.[1] Traditionally, foods of animal origin such as eggs, meat, and dairy products have dominated outbreaks of foodborne illness.[2] However, with the continual demand for fresh produce, better outbreak surveillance, and improved methods for detecting pathogens, new food vehicles have been associated with outbreaks, such as semi-dried tomatoes,[3] fresh garlic,[4] peanuts,[5] cantaloupe or rockmelon,[6] papaya,[7] and baby corn.[8]

Fruit and vegetables can be contaminated with pathogenic microbes at any stage of the production process and this can cause human disease.[1] Fresh fruit and vegetables are frequently eaten raw or with minimal processing, and this lack of a pathogen kill step increases the risk of foodborne illness.[9] Common bacterial pathogens associated with fresh produce outbreaks include *Escherichia coli*, *Salmonella* spp., and *Listeria monocytogenes*. These can persist in soil, water, or manure, posing a contamination risk.[10]

In Australia, there are around 4.1 million cases of foodborne gastroenteritis annually, with an estimated financial burden of $AUD 1.2 billion per year.[11,12] Along with the socioeconomic cost, outbreaks have been shown to have a lasting effect on the purchasing behaviours of consumers, leading to local and global trade disturbances and associated economic impacts.[13] To date there has not been a detailed, nationwide review of Australian outbreaks of foodborne illness due to fresh produce. As outbreak data is critical both economically and in public health, this review aims to define the state of foodborne disease outbreaks that pertain to fresh produce in Australia. The specific objectives of this study are therefore: (i) to summarise the trends among outbreaks associated with fresh produce; (ii) to identify the most frequently reported aetiological agents, food preparation settings and produce types implicated in these outbreaks; and (iii) to describe the geography and seasonality of fresh produce outbreaks, using data reported by OzFoodNet, Australia's foodborne disease surveillance system, from 2001 to 2017.

Methods

Data source

OzFoodNet is the national network for foodborne disease surveillance and response in Australia and has conducted surveillance of enteric and foodborne outbreaks since 2000.[14] OzFoodNet epidemiologists across Australia enter data on all foodborne disease outbreaks into a national database. Data were obtained from OzFoodNet's Outbreak Register to examine foodborne outbreaks associated with fresh produce during the years 2001–2017. A limitation of the dataset is that prior to 2002, outbreaks in the Northern Territory and in areas of New South Wales were not included in the reporting. Outbreak reports recorded as 'foodborne' or 'suspected foodborne' that included a fresh produce item as the vehicle were extracted from the register. Data collected for each outbreak included the setting of the outbreak, where the food was prepared, the symptom onset date for the first case in the outbreak, the number of symptomatic cases, the number of cases that were confirmed by laboratory analysis, the number of cases hospitalised, the number who died during the outbreak, the median incubation period of cases, the median duration of illness, epidemiological methods (case series, case control study, cohort study, descriptive study, no formal study), evidence (statistical, microbiological, descriptive) and the organism (known or suspected) responsible for the illness. For large outbreaks of foodborne disease, published research articles, publicly available OzFoodNet quarterly and annual reports, and Food Standards Australia New Zealand (FSANZ) reports were used to identify the most accurate total number of cases.

Inclusion, exclusion, and categorisation criteria

A fresh produce outbreak was defined by the occurrence of two or more cases of a similar illness after consumption of a common food or meal containing uncooked fresh produce. The aetiological agents were the bacteria or viruses identified as causing the foodborne disease as described by the United States Centers for Disease Control and Prevention (CDC).[15] The food vehicle field was manually reviewed and outbreaks that did not include fresh produce, where the produce item(s) were cooked, or where the food vehicle was unknown, were excluded from this review. Outbreaks with no statistical, microbiological, or descriptive evidence that implicated the food vehicle were also excluded. Additionally, outbreaks that were deemed unlikely to have been caused by fresh produce items were excluded. These included outbreaks due to *Bacillus cereus* and rotavirus, or if the dish contained egg or chicken and the aetiological agent was *Salmonella* Typhimurium[16–18] or *Campylobacter*. In total, 88 outbreaks were excluded from the study.

Outbreaks were categorised by whether the food vehicle contained one or multiple ingredients. Single-ingredient outbreaks were further categorised into i) primary fresh produce: raw agricultural product such as melons or salad leaves; and ii) minimally processed fresh produce: macerated, semi-dried or juiced fresh produce. Multiple-ingredient outbreaks were categorised into iii) mixed dish: the fresh produce item was a component of a mixed dish that may have contained non-fresh-produce ingredients (e.g., meat, dairy, etc.); and iv) salad: a mixture of raw fresh produce items. Seasonality was assigned by the month of the first illness in the outbreak. Microsoft Excel (version 16.54) was used to analyse the data and to generate figures.

Results

Summary of outbreaks

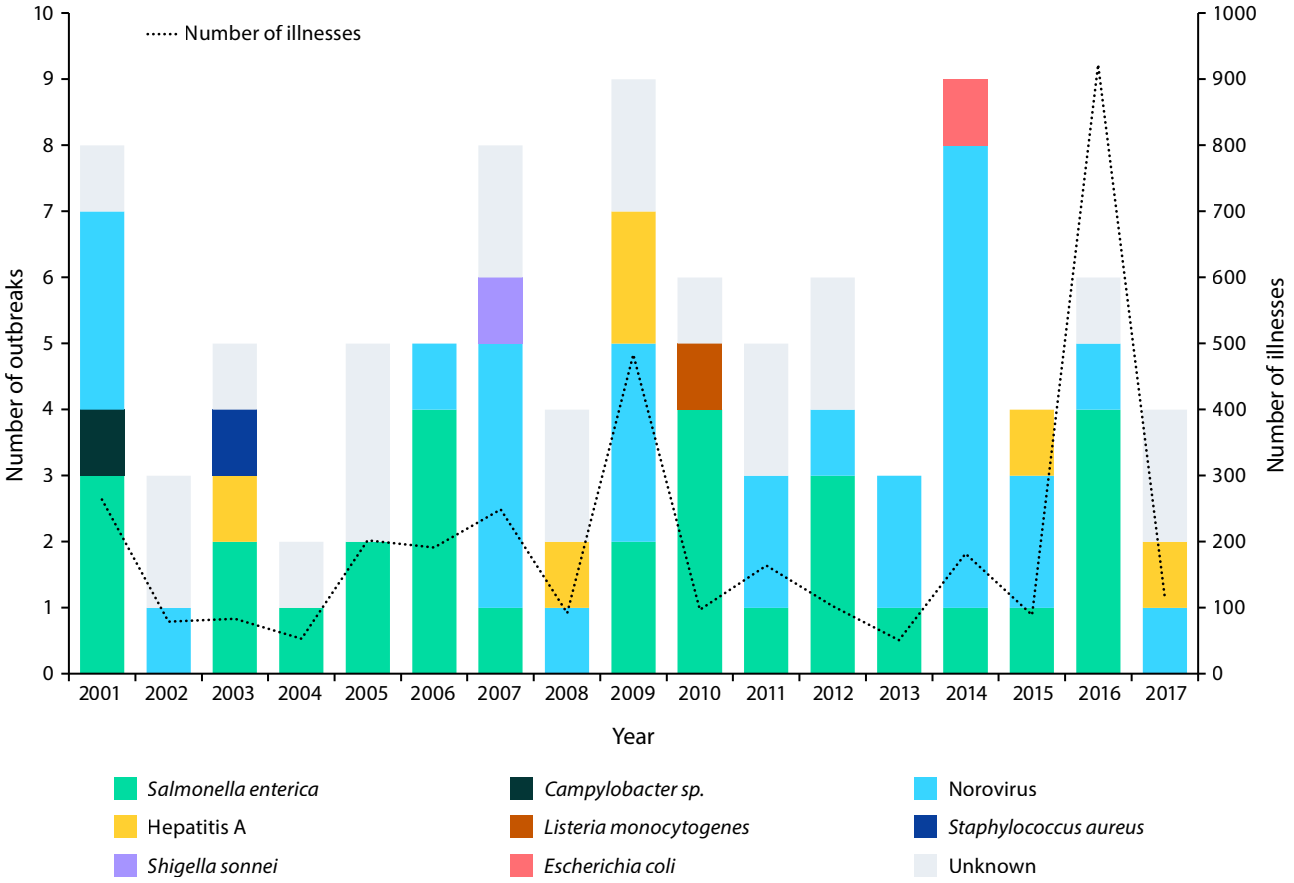
Ninety-two confirmed or suspected foodborne outbreaks associated with fresh produce were reported to OzFoodNet from 2001 to 2017 (Figure 1, Table A.1). These resulted in 3,422 reported illnesses, 446 hospitalisations and four deaths. The deaths occurred in outbreaks that implicated semi-dried tomatoes (2009) or melons (2010 and 2017) as the food vehicle. Within each outbreak, the median age of case-patients ranged from 4 to 78 years old.

Epidemiological investigations were conducted on 95.6% of the fresh produce outbreaks (88/92; Table A.1), with case series (34.8%; 32/92) and cohort studies (41.3%; 38/92) being the most common. Statistical evidence was used to implicate a food vehicle in 58.7% (54/92) and compelling descriptive evidence was used in 37.0% (34/92) of outbreak investigations. Although all outbreaks had some form of evidence, only 33.7% (31/92) had laboratory evidence (Table A.1).

Aetiological agents associated with outbreaks

An aetiological agent was confirmed in 76.1% (70/92) of the outbreaks. The most frequently implicated agents were *S. enterica* (32.6%; 30/92) and Norovirus (31.5%; 29/92) (Figure 1, Table A.1). Among the thirty *S. enterica* outbreaks, Typhimurium (40%; 12/30) and Saintpaul (13.3%; 4/30) were the most frequent serotypes. There was only one outbreak of *L. monocytogenes* and this led to the highest proportion of hospitalisations of any aetiological agent (88.9%; 8/9) and two fatalities. Hepatitis A infections also led to a high proportion of hospitalisations (38.3%; 195/509) and one fatality. The proportion of *Salmonella* illnesses that led to hospitalisations was 13.3% (220/1652) with one fatality, and Norovirus had the lowest hospitalisation rate at 1.8% (14/760).

Figure 1: Number of outbreaks and illnesses associated with fresh produce, including the aetiological agent associated with each outbreak, Australia, 2001–2017[a]



a Data source: OzFoodNet.

Outbreaks linked to single-ingredient primary fresh produce

Single-ingredient fresh produce outbreaks included those attributed to a single primary fresh produce item (e.g., bean sprouts or melons) and those with a single produce item that was minimally processed (e.g., frozen berries or semi-dried tomatoes) (Table 1). Twenty-one of the 92 (22.8%) outbreaks were associated with a single fresh produce ingredient. The largest outbreak was due to bean sprouts contaminated with *Salmonella* Saintpaul in 2016, where 419 illness and 76 hospitalisations were reported. The second largest single-ingredient outbreak was attributed to imported semi-dried tomatoes contaminated with Hepatitis A in 2009, with 372 illness and 169 hospitalisations reported. Among the single-ingredient outbreaks, the most commonly implicated aetiological agent was *S. enterica* (n = 15) followed by Hepatitis A virus (n = 4). Outbreaks where a primary fresh produce item was implicated as the food source resulted in 1,854 reported illnesses and 385 hospitalisations.

Settings and categories of fresh produce outbreaks

Fourteen different settings were associated with the 92 fresh produce outbreaks (Figure 2). Restaurant (45.7%; 42/92) and commercial catering (15.2%; 14/92) settings had the highest number of outbreaks, and these were frequently due to multiple-ingredient mixed dishes and salads containing fresh produce. Across all fresh produce outbreaks, salad (43.5%; 40/92) and mixed dish (29.3%; 27/92) categories were more commonly implicated than were single-ingredient primary fresh produce (20.7%; 19/92) and minimally processed fresh produce (6.5%; 6/92) (Figure 2A). Primary produce (42.7%; 1462/3422) and salads (26.1%; 894/3422) led to the highest number of illnesses. For these, the settings most implicated were the community (36.2%; 1239/3422) followed by restaurants (23.3%; 798/3422) and imported food (16.4%; 560/3422) (Figure 2B).

Seasonality of fresh produce outbreaks

Fresh produce outbreaks were more common in the warmer months and became less frequent during the southern hemisphere winter (June–August; Figure 3). Across all outbreaks, *S. enterica* was the most common aetiological agent (32.6%; 30/92), occurring in all seasons.

Geographical distribution of outbreaks

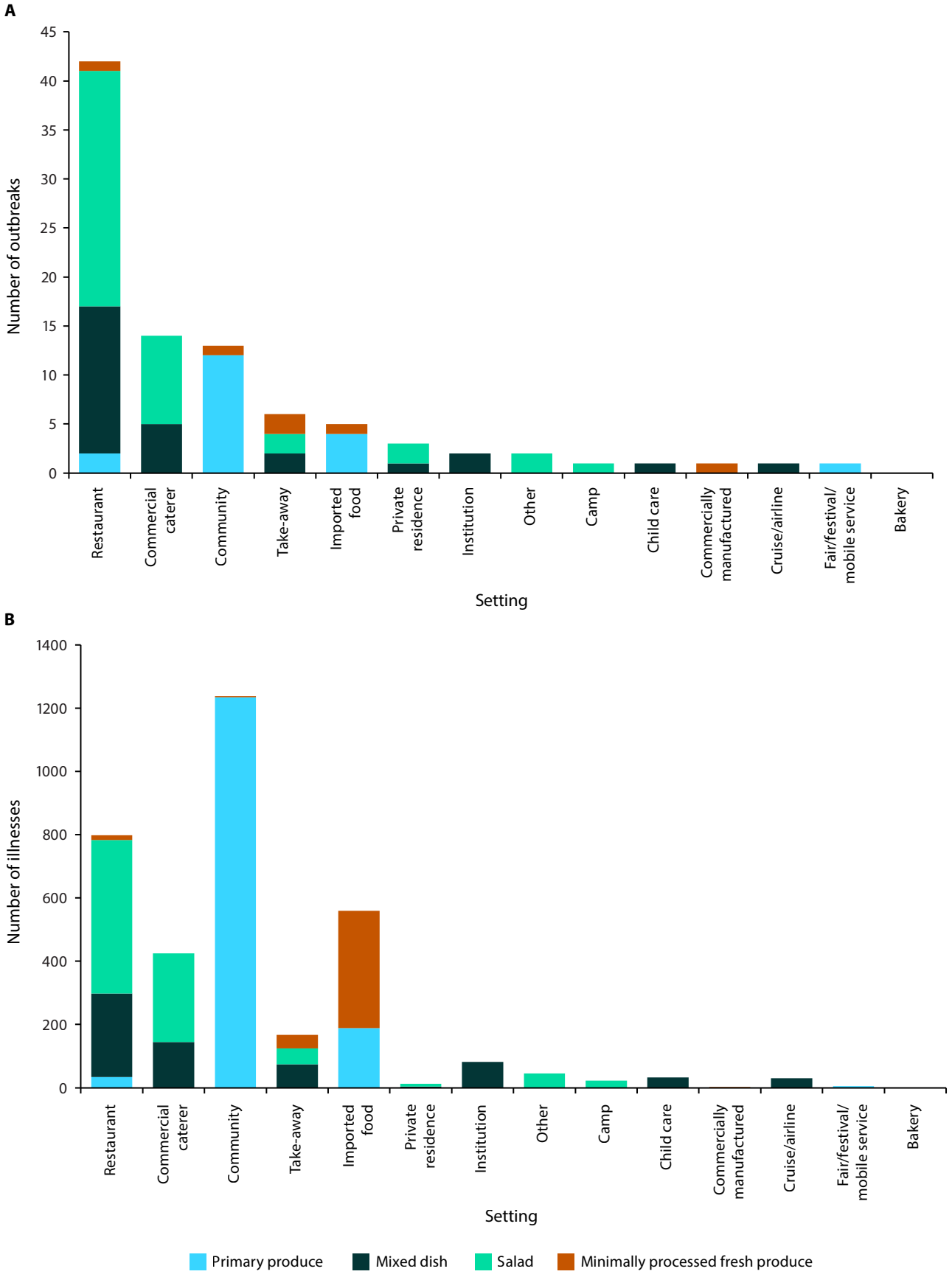
Outbreaks were reported in all eight Australian states and territories (Table A.1), with the largest number of outbreaks occurring in Victoria (22.8%; 21/92), followed by New South Wales (21.7%; 20/92) and Western Australia (18.5%; 17/92). There were eleven multi-state outbreaks (11.9%; 11/92).

Table 1: Fresh produce outbreaks attributed to a single-ingredient fresh produce item reported to OzFoodNet from 2001 to 2017

	Food	Jurisdiction[a]	Year	Organism	Category	Setting	Ill	Hospitalised	Additional references
1	Imported peanuts	MJOI	2001	*Salmonella* Stanley and *Salmonella* Newport	Imported primary produce	Community	32	3	5; 19-21
2	Shredded iceberg lettuce	Qld	2001	*Salmonella* Bovismorbificans	Minimally processed fresh produce	National franchised fast food	36	6	19; 22
3	Cucumber (suspected)	Vic.	2003	*Salmonella* Litchfield and *Salmonella* Kinondoni	Primary produce	Community	6	1	23
4	Alfalfa sprouts	WA	2005	*Salmonella* Oranienburg	Primary produce	Community	126	30	24; 25
5	Alfalfa sprouts	Vic.	2006	*Salmonella* Oranienburg	Primary produce	Community	15	2	26; 27
6	Paw paw/papaya	MJOI	2006	*Salmonella* Litchfield	Primary produce	Community	26	5	7; 21; 26; 28
7	Rockmelon	MJOI	2006	*Salmonella* Saintpaul	Primary produce	Community	115	9	6; 21; 26; 28
8	Imported baby corn	Qld	2007	*Shigella sonnei*	Primary produce	Community	55	3	8; 21; 29; 30
9	Fresh chillies used to prepare chilli sauce	NSW	2009	*Salmonella* Chester	Minimally processed fresh produce	Restaurant	14	2	31
10	Imported semi-dried tomatoes	MJOI	2009	Hepatitis A virus	Minimally processed fresh produce	Community	372	169 (1 fatality)	3; 21; 31
11	Frozen berries	WA	2009	Hepatitis A virus	Primary produce	Other	4	1	31; 32
12	Paw paw/papaya	WA	2009	*Salmonella* Saintpaul	Primary produce	Community	17	3	31
13	Melons	MJOI	2010	*Listeria monocytogenes*	Primary produce	Community	9	8 (2 fatalities)	33
14	Suspect mango	NT	2011	*Salmonella* Saintpaul	Primary produce	Fair/festival/ mobile service	5	0	34
15	Raw almonds	MJOI	2012	*Salmonella* Typhimurium	Primary produce	Community	43	7	35
16	Imported frozen berries	MJOI	2015	Hepatitis A virus	Imported primary produce	Community	67	16	36; 37
17	Snow pea sprouts	WA	2015	*Salmonella* Muenchen	Primary produce	Community	4	2	38
18	Bagged salad products	MJOI	2016	*Salmonella* Anatum	Primary produce	Community	311	24	39
19	Mung bean sprouts	MJOI	2016	*Salmonella* Saintpaul	Primary produce	Community	419	76	39
20	Rockmelon	MJOI	2016	*Salmonella* Hvittingfoss	Primary produce	Community	144	13 (1 fatality)	39
21	Imported frozen berries	MJOI	2017	Hepatitis A virus	Imported primary produce	Community	34	5	37; 40

a ACT: Australian Capital Territory; NSW: New South Wales; NT: Northern Territory; Qld: Queensland; SA: South Australia; Tas.: Tasmania; Vic.: Victoria; WA: Western Australia; MJOI: multi-jurisdiction outbreak investigation.

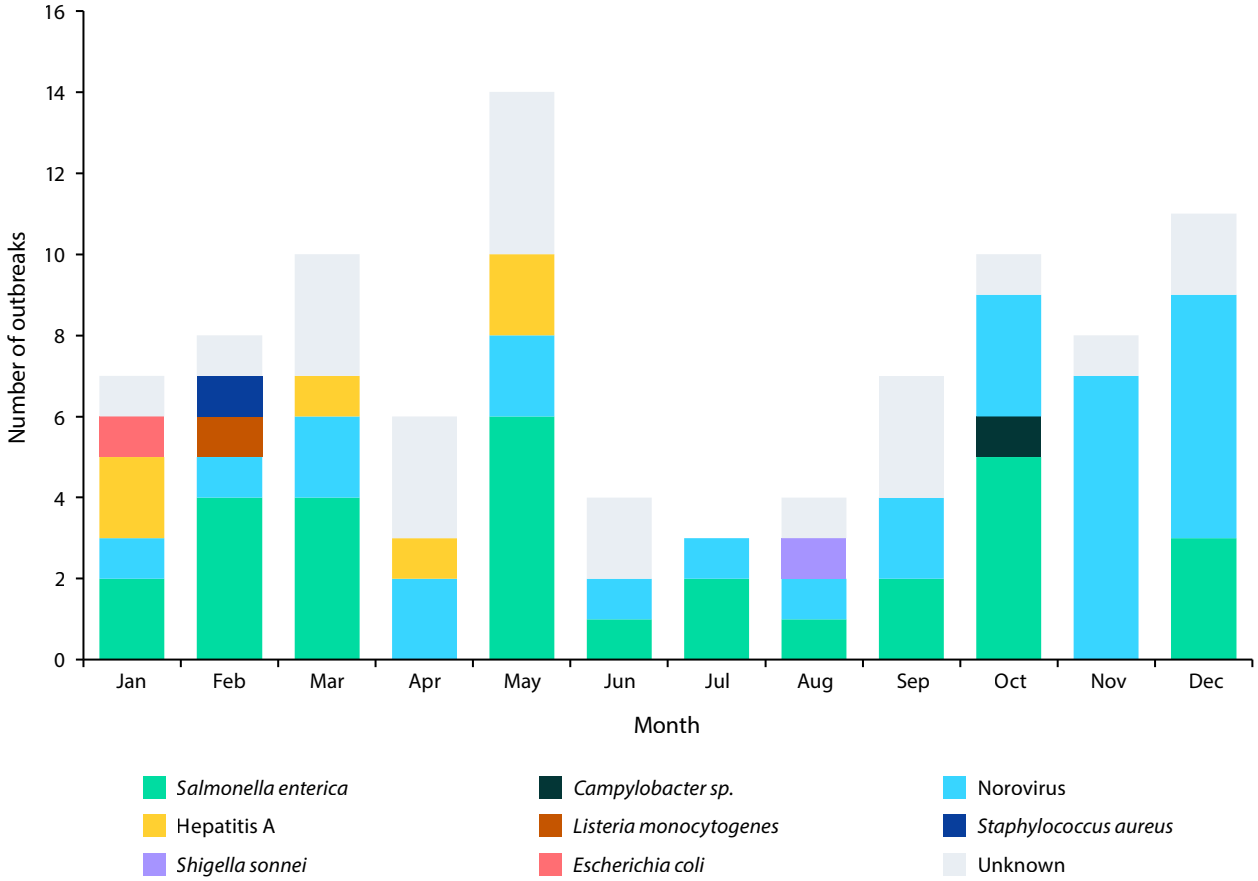
Figure 2: Settings of consumption of foods implicated in fresh produce outbreaks, ordered by (A) the number of outbreaks and (B) the number of illnesses associated with each setting, Australia, 2001–2017[a,b]



a Source: OzFoodNet.

b Colours indicate the food category implicated in the outbreaks.

Figure 3: Seasonal distribution of outbreaks associated with fresh produce in Australia, 2001–2017[a]



a Source: OzFoodNet; n = 92.

Discussion

Fresh-produce-associated outbreaks were an important cause of morbidity and mortality in Australia during 2001–2017. Across the 17-year period analysed, *S. enterica* was the most commonly reported aetiological agent, accounting for 32.6% of the outbreaks. *Salmonella enterica* serotype Saintpaul was a significant cause of fresh-produce-associated illness and was implicated in four outbreaks, resulting in 556 illnesses and 88 hospitalisations, with two widely publicised outbreaks involving rockmelons in 2006 and mung bean sprouts in 2016. Serotype Saintpaul has also been implicated in large outbreaks internationally, including a hot chili pepper outbreak in the United States of America (USA) in 2008 that resulted in 1,500 illnesses.[41] In an international study, Li et al. (2018)[42] reviewed outbreaks from 2010–2015 and reported that *S. enterica* contributed to 22.9% of fresh-produce-associated outbreaks in the United States, 16% in the European Union, 15.8% in Japan, 3.8% in New Zealand and 15% in Canada. In response to the problems with *Salmonella*, Australia's 'Foodborne Illness Reduction Strategy 2018–2021+' was introduced with the aim to reduce the incidence of foodborne *Salmonella* infections,[43] and by 2021 there was a 20% decrease in all salmonellosis cases compared to previous years.[44] Ongoing studies will be required to determine the efficacy of this strategy in reducing *Salmonella* risks specifically relating to fresh produce. The current study highlights the prevalence of *S. enterica* as a contaminant of fresh produce in Australia, as well as the importance of policy responses in mitigating the risks associated with *Salmonella*.

Norovirus was the second most common aetiological agent behind *Salmonella* in this study. Norovirus is a major source of fresh produce outbreaks globally,[9] and was the most frequent aetiological agent linked to produce-associated outbreaks in the USA from 1998–2013[45] and in the European Union from 2004–2012.[46] The vast majority of all Norovirus outbreaks in this study (93.5%) were traced to restaurants or commercial catering settings, consistent with its transmission from person to person and from food handlers to food to consumers.[47] In Australia, norovirus infections are not required to be reported to public health surveillance, making it difficult to detect norovirus outbreaks.

Hepatitis A was also an important cause of the reported outbreaks. Imported tomatoes contaminated with Hepatitis A virus led to a severe outbreak of foodborne illness in 2009, with 419 illnesses and 169 hospitalisations.[3] During the same time period as the current study, Hepatitis A outbreaks due to imported contaminated semi-dried tomatoes were reported in France and the Netherlands.[48,49] Hepatitis A virus was also linked to three frozen berry outbreaks in the current study, with the two largest of these involving imported produce. Hepatitis A virus and human norovirus are both temperature-stable viruses that can survive freezing,[50] so for minimally processed fresh produce items such as tomatoes and berries, contamination of imported and/or frozen fresh produce with these viruses poses a significant public health risk.[37] The current study highlights the varied manifestations of viral outbreaks. Norovirus infections were frequently associated with food settings and meals where food handlers were likely to be an important source of contamination, as norovirus is highly infectious and causes explosive outbreaks of gastroenteritis.[51] In contrast, Hepatitis A virus outbreaks were rarer but led to a greater proportion of cases hospitalised, and these were more frequently linked to contaminated single-ingredient primary fresh produce items such as tomatoes and berries imported from countries where hepatitis A infection is endemic.[37]

Sprouts were the most common single-ingredient primary fresh produce item associated with outbreaks of gastroenteritis. Sprouts are recognised as a significant horticultural cause of foodborne disease outbreaks globally,[52] as they are often eaten raw and the warm and moist sprouting conditions promote the growth of bacteria, including pathogens.[53] The largest outbreak in the dataset occurred in 2016, when contamination of mung bean sprouts by *Salmonella* Saintpaul led to 419 illness and 76 hospitalisations. Sprouts have been linked to serious outbreaks internationally, with a single *E. coli* O104:H4 outbreak due to consumption of Fenugreek sprouts in 2011 involving 16 countries with more than 4000 illnesses.[54] After large sprout outbreaks occurred in Australia in 2005–2006, food standards were implemented to help decrease foodborne illnesses relating to their consumption.[55,56] Despite this, sprout-related outbreaks occurred in 2015, 2016 and 2018.[39,57–59] In this study, all sprout-related outbreaks involved *S. enterica*, which is an association that has been reported across the world.[46,55,60,61]

After sprouts, melons were the primary fresh produce item most frequently linked to outbreaks. Melon-associated outbreaks have continued to occur beyond the date range of the dataset, with the consumption of rockmelons contaminated with *L. monocytogenes* resulting in 22 cases and seven fatalities in 2018.[62] In response to these outbreaks, production and processing standards aimed at mitigating foodborne illnesses associated with melons were enacted in Australia in 2022.[63] Melons are also an important source of foodborne disease outbreaks in the United States, with 28 outbreaks linked to the consumption of melon during 2001–2017.[64] The most severe of these outbreaks was caused by the contamination of rockmelons with *L. monocytogenes*, resulting in 147 cases and 33 fatalities.[65] Strict adherence to food safety standards is crucial to prevent further instances of foodborne illnesses related to melons.

Analysis of the settings and food categories revealed that there were two main types of foodborne outbreaks associated with fresh produce in this study. First were outbreaks in the community resulting from the contamination of a single-ingredient primary fresh produce item. These were less frequent but led to the highest number of illnesses and fatalities, presumably because primary fresh produce can cause a large number of illnesses due to their widespread distribution, difficulties in traceback identification, and cross-contamination and pathogen growth along the supply chain.[66] Second were outbreaks associated with restaurant and commercial caterer settings, where the contaminated food categories were mainly salads and mixed meals. These foods are prepared and served in ways that can facilitate pathogen transmission and cross contamination through worker handling, leading to more frequent but comparatively smaller outbreaks.

Outbreaks linked with *Salmonella* were reported in all seasons, with the highest proportion occurring in the warmest months (December–February). A positive association of temperature with *Salmonella* outbreaks has been reported in Australia,[67] Canada,[68] South Korea,[69] and Europe,[70] and may be due to increased growth of the enteric bacteria at higher temperatures as well as to the behavioural patterns of consumers.[71–73] In contrast, spring time had the highest number of viral outbreaks (12/36), which is a pattern observed previously.[74] Different foodborne pathogens have different mechanisms of growth and transmission pathways that lead to seasonal outbreaks patterns,[75] consistent with the findings of the current study.

A limitation of this dataset obtained from OzFoodNet is that the outbreaks reported in the register represent only a proportion of those occurring in the community. The degree of under-representation is unknown and is most likely variable by disease and jurisdiction. In general, passive surveillance systems are likely to be biased toward larger outbreaks, as smaller outbreaks are often undetected, not investigated, or lack sufficient evidence for inclusion in the database. Another limitation is misclassification bias, as all outbreaks were labelled as fresh produce-associated but the source of contamination may have been other foods in the mixed or multiple ingredients food categories. This may have resulted in over-representation of the number of outbreaks classified as 'fresh-produce-associated'. This dataset highlights the need for improved methods for pathogen detection in foodborne outbreak investigations that can better pinpoint the source of contamination.

We conclude that the consumption of fresh produce in Australia produces a significant but relatively small number of outbreaks of foodborne illness that has remained largely unchanged in terms of size and aetiological agent across the 16 years analysed in this report. Consistent with global patterns, sprouts and melons are significant vehicles of bacterial pathogens and can result in severe illness.

Ethics

Permission for data access was granted by OzFoodNet and ethics approval was obtained through the Australian National University Human Research Ethics Committee (2018/652).

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Appendix A

Table A.1: Fresh produce outbreaks of gastroenteritis reported to OzFoodNet from 2001 to 2017

Food	Jurisdiction[a]	Month[b]	Year	Organism	Category	Setting	Ill	Lab confirmed	Hospitalised	Died	Median age	Evidence[c]	Epidemiological methods
Suspected cold chicken salad	Vic.	Feb	2001	Unknown	Salad	Restaurant	5	0	0	0	37	CD	Case series
Imported peanuts	MJOI	May	2001	*Salmonella enterica* serotype Stanley, *Salmonella enterica* serotype Newport	Primary produce	Imported food	32	32	3	0	7	CD, S, M	Case series
Shredded iceberg lettuce	Qld	May	2001	*Salmonella enterica* serotype Bovismorbificans	Minimally processed fresh produce	Take-away	36	36	6	0	22.5	S, M	Case control study
Tomato and cucumber salad	Vic.	Oct	2001	*Campylobacter* sp.	Salad	Restaurant	27	9	0	0	40	S	Cohort study
Crannachan dessert (raw berries)	WA	Oct	2001	Norovirus	Mixed dish	Restaurant	56	1	0	0	0	S	Cohort study
Mango pudding dessert	SA	Dec	2001	*Salmonella enterica* serotype Typhimurium	Mixed dish	Restaurant	28	19	0	0	28	S, M	Case control study
Caesar salad	WA	Dec	2001	Norovirus	Salad	Restaurant	24	6	0	0	36	S	Cohort study
Chicken spinach salad	WA	Dec	2001	Norovirus	Salad	Restaurant	56	1	0	0	37	S, M	Cohort study
Seafood salad; ravioli; grilled chicken	WA	Feb	2002	Norovirus	Salad	Restaurant	60	7	2	0	45	S	Cohort study
Meal of pumpkin soup, roast pork, vegetables, fruit salad and icecream	NSW	Sep	2002	Unknown	Mixed dish	Restaurant	4	0	0	0	Unknown	CD	No formal study
Roast beef, rice noodle salad	NSW	Nov	2002	Unknown	Salad	Restaurant	15	0	1	0	62	S	Cohort study
Rice salad	NSW	Feb	2003	*Salmonella enterica* serotype Typhimurium	Salad	Restaurant	11	1	1	0	28.3	M	Case series
Pasta salad	Qld	Feb	2003	*Staphylococcus aureus*	Salad	Other	16	2	0	0	30.9	M	No formal study

Food	Jurisdiction[a]	Month[b]	Year	Organism	Category	Setting	Ill	Lab confirmed	Hospitalised	Died	Median age	Evidence[c]	Epidemiological methods
Coleslaw	Tas.	May	2003	Hepatitis A	Salad	Camp	22	22	2	0	18	S	Cohort study
Suspected cucumber	Vic.	May	2003	*Salmonella enterica* serotype Litchfield	Primary produce	Community	6	6	1	0	Unknown	CD, M	Case series
Vegetable and chilli dish	Vic.	Oct	2003	Unknown	Mixed dish	Restaurant	28	0	0	0	20.5	S	Cohort study
Suspected gourmet rolls including red onion	Vic.	May	2004	*Salmonella enterica* serotype Typhimurium	Mixed dish	Commercial caterer	28	14	3	0	34.5	S, M	Cohort study
Suspected buffet meal with cold salad	Qld	Jun	2004	Unknown	Mixed dish	Restaurant	25	0	0	0	67	CD	Cohort study
Chicken Caesar salad and chicken burger	NSW	Mar	2005	Unknown	Mixed dish	Restaurant	3	0	2	0	26	CD	No formal study
Self serve salad bar	NSW	May	2005	Unknown	Mixed dish	Institution	37	0	1	0	20	CD	Case control study and cohort study
Suspected coleslaw	NSW	Aug	2005	Unknown	Salad	Restaurant	3	0	0	0	Unknown	CD	Case series
Suspected to be ready to eat food such as hand cut fruit and sandwiches	NSW	Oct	2005	*Salmonella enterica* serotype Typhimurium	Mixed dish	Child care	33	10	0	0	3.6	S	Cohort study
Alfalfa sprouts	WA	Oct	2005	*Salmonella enterica* serotype Oranienburg	Primary produce	Community	126	126	30	0	38	S, M	Case control study
Alfalfa sprouts	Vic.	May	2006	*Salmonella enterica* serotype Oranienburg	Primary produce	Community	15	0	2	0	Unknown	S, M	Case series
Sweet potato and fetta cheese salad	SA	Jun	2006	*Salmonella enterica* serotype Typhimurium	Salad	Restaurant	6	4	0	0	26	S	Cohort study
Rockmelon	MJOI	Sep	2006	*Salmonella enterica* serotype Saintpaul	Primary produce	Community	115	115	9	0	22	S, M	Case control study
Pawpaw	MJOI	Oct	2006	*Salmonella enterica* serotype Litchfield	Primary produce	Community	26	26	5	0	22	S, M	Case control study

Food	Jurisdiction[a]	Month[b]	Year	Organism	Category	Setting	Ill	Lab confirmed	Hospitalised	Died	Median age	Evidence[c]	Epidemiological methods
Green salad	WA	Nov	2006	Norovirus	Salad	Other	29	10	0	0	73	S	Cohort study
Hommus and tabouli	NSW	Mar	2007	*Salmonella enterica* serotype Typhimurium	Mixed dish	Take-away	71	44	10	0	22	M	Case series
Ham; salad; bread	Qld	Mar	2007	Norovirus	Mixed dish	Institution	45	2	0	0	38	S	Cohort study
Penne pasta salad (suspected)	Vic.	Apr	2007	Unknown	Salad	Commercial caterer	25	0	0	0	19	S	Cohort study
Fresh fruit juices suspected	NSW	May	2007	Unknown	Minimally processed fresh produce	Take-away	6	0	0	0	28	CD	Case series
Imported baby corn	Qld	Aug	2007	*Shigella sonnei*	Primary produce	Imported food	55	12	3	0	33	CD, S, M	Case series
Mixed salad	Qld	Aug	2007	Norovirus	Salad	Restaurant	24	10	0	0	27.4	S	Case control study and cohort study
Fruit salad	Vic.	Sep	2007	Norovirus	Salad	Commercial caterer	18	15	1	0	73.5	S	Cohort study
Suspected salad	Qld	Dec	2007	Norovirus	Salad	Private residence	5	2	0	0	37	CD	Case series
Deli meat & salad dish	Qld	Mar	2008	Norovirus	Mixed dish	Commercial caterer	56	8	0	0	35.5	S	Cohort study
Fattouch salad	NSW	May	2008	Unknown	Salad	Restaurant	17	0	0	0	Unknown	S	Cohort study
Salads and sandwiches	Vic.	May	2008	Hepatitis A	Mixed dish	Restaurant	10	10	2	0	37.5	CD	Case series
Ready to eat foods – salads and garnishes	Vic.	May	2008	Unknown	Mixed dish	Restaurant	9	0	0	0	37.5	CD	Case series
Fresh chillies used to prepare chilli sauce	NSW	Jan	2009	*Salmonella enterica* serotype Chester	Minimally processed fresh produce	Restaurant	14	7	2	0	Unknown	CD, M	Case series
Semi-dried tomatoes	MJOI	Mar	2009	Hepatitis A	Minimally processed fresh produce	Imported food	372	300	169	1	38	CD, S, M	Case control study
Lasagne, chicken Caesar salad	NSW	Apr	2009	Unknown	Mixed dish	Restaurant	5	0	0	0	Unknown	CD	Case control study

Food	Jurisdiction[a]	Month[b]	Year	Organism	Category	Setting	Ill	Lab confirmed	Hospitalised	Died	Median age	Evidence[c]	Epidemiological methods
Frozen berries	WA	Apr	2009	Hepatitis A	Minimally processed fresh produce	Community	4	4	1	0	30	CD, M	Case series
Pawpaw	WA	Aug	2009	*Salmonella enterica* serotype Saintpaul	Primary produce	Community	17	17	3	0	18	M	Case series
A salad meal or a meal containing salad	NSW	Sep	2009	Unknown	Salad	Restaurant	13	3	0	0	46	CD	Cohort study
Chicken Caesar salad; roast chicken	Qld	Oct	2009	Norovirus	Mixed dish	Restaurant	23	6	0	0	39	S	Cohort study
Berry cheesecake	SA	Nov	2009	Norovirus	Mixed dish	Restaurant	21	5	0	0	65	S	Cohort study
Green salad	Tas.	Nov	2009	Norovirus	Salad	Commercial caterer	14	1	0	0	48.5	CD, S	Cohort study
Melons	MJOI	Feb	2010	*Listeria monocytogenes*	Primary produce	Community	9	9	8	2	78	CD, S, M	Case series and case control study
Pasta salad	Vic.	Feb	2010	*Salmonella enterica* serotype Typhimurium	Salad	Commercial caterer	15	6	1	0	12.5	M	Cohort study
Orange and mango fruit drink	NSW	Mar	2010	Unknown	Minimally processed fresh produce	Commercially manufactured	3	0	0	0	20	CD	Case series
Suspected peanut/ cashew mixture	NSW	Mar	2010	*Salmonella enterica* serotype Typhimurium	Primary produce	Restaurant	19	9	0	0	38	CD	Case series
Assorted salads	ACT	Oct	2010	*Salmonella enterica* serotype Typhimurium	Salad	Take-away	47	41	5	0	29	M	Case series
Banana milkshake	Qld	Dec	2010	*Salmonella enterica* serotype Typhimurium	Mixed dish	Private residence	4	4	2	0	6	CD	Case series
Fruit	Vic.	Jun	2011	Norovirus	Primary produce	Restaurant	15	5	0	0	39	S	Cohort study
Salad	WA	Jul	2011	Norovirus	Salad	Restaurant	53	1	0	0	28	CD	Case control study

Food	Jurisdiction[a]	Month[b]	Year	Organism	Category	Setting	Ill	Lab confirmed	Hospitalised	Died	Median age	Evidence[c]	Epidemiological methods
Salad of poached prawns with Thai herbs	NSW	Sep	2011	Unknown	Salad	Commercial caterer	87	0	0	0	15.2	S	Cohort study
Suspect mango	NT	Sep	2011	*Salmonella enterica* serotype Saintpaul	Primary produce	Fair/festival/ mobile service	5	3	0	0	5	CD	Case series
Moroccan chicken salad	Vic.	Dec	2011	Unknown	Salad	Restaurant	4	1	1	0	19	S	Cohort study
Prawn salad rolls	Qld	Jan	2012	*Salmonella enterica* serotype Infantis	Mixed dish	Restaurant	2	2	2	0	62	M	Case series
Grapes and caramel slice	WA	Jan	2012	Unknown	Mixed dish	Commercial caterer	21	0	0	0	46	S	Case control study
Multiple salads	WA	Feb	2012	*Salmonella enterica* serotype Anatum	Salad	Take-away	4	4	0	0	39	M	Case series
Lamb salad	NSW	Mar	2012	Unknown	Salad	Commercial caterer	16	0	1	0	44	S	Cohort study
Raw almonds	MJOI	Jul	2012	*Salmonella enterica* serotype Typhimurium	Primary produce	Community	43	43	7	0	33	M	Case series
Salads	Vic.	Oct	2012	Norovirus	Salad	Restaurant	17	2	1	0	36	CD	Case series
Salad	Vic.	Jan	2013	Norovirus	Salad	Restaurant	7	4	0	0	54	CD	Case series
Suspect salad	Tas.	Dec	2013	*Salmonella enterica* serotype Mississippi	Salad	Restaurant	36	11	3	0	51	S	Cohort study
Salad	WA	Dec	2013	Norovirus	Salad	Restaurant	8	3	0	0	Unknown	CD	Case series
Tabouli or parsley	ACT	Jan	2014	*Escherichia coli*	Mixed dish	Take-away	3	0	0	0	26	M	Case series
Garden salad	NSW	May	2014	Norovirus	Salad	Restaurant	6	1	0	0	Unknown	CD	Case series
Grain salad	Vic.	May	2014	Norovirus	Salad	Restaurant	46	15	0	0	33	S	Cohort study
Lamb shanks or salad	WA	May	2014	*Salmonella enterica* serotype Typhimurium	Mixed dish	Restaurant	5	2	4	0	28	S	Case control study
Suspect fruit salad	Tas.	Nov	2014	Norovirus	Salad	Restaurant	9	2	1	0	73	S	Cohort study
Lamb, lettuce and tomato	Vic.	Nov	2014	Norovirus	Mixed dish	Commercial caterer	19	4	2	0	21	S	Cohort study

Food	Jurisdiction[a]	Month[b]	Year	Organism	Category	Setting	Ill	Lab confirmed	Hospitalised	Died	Median age	Evidence[c]	Epidemiological methods
Brownies or cut fresh fruit	Vic.	Nov	2014	Norovirus	Mixed dish	Commercial caterer	20	3	2	0	52	S	Cohort study
Thai beef salad	Vic.	Nov	2014	Norovirus	Salad	Commercial caterer	53	3	1	0	46	S	Case control study
Leafy salad (green salad or prawn salad)	WA	Dec	2014	Norovirus	Salad	Restaurant	21	1	0	0	51	S	Cohort study
Imported frozen berries	MJOI	Jan	2015	Hepatitis A	Primary produce	Imported food	67	35	16	0	32	S, M	Case control study
Salad – young leaves with house dressing	Vic.	Sep	2015	Norovirus	Salad	Restaurant	9	2	0	0	52	S	Case control study
Snow pea sprouts	WA	Oct	2015	*Salmonella enterica* serotype Muenchen	Primary produce	Community	4	4	2	0	62	CD, M	Case series
Multiple salads	WA	Dec	2015	Norovirus	Salad	Restaurant	9	1	0	0	66	CD, S	Cohort study
Bagged salad products	MJOI	Feb	2016	*Salmonella enterica* serotype Anatum	Primary produce	Community	311	311	24	0	45	CD, M	Case control study
Mung bean sprouts	MJOI	Mar	2016	*Salmonella enterica* serotype Saintpaul	Primary produce	Community	419	124	76	0	34	CD, S, M	Case series and case control study
Banana smoothie; berry smoothie; and fish	WA	Mar	2016	*Salmonella enterica* serotype Enteritidis	Mixed dish	Cruise/airline	30	13	10	0	62	S	Case control study
Side salad served with meals	Tas.	Apr	2016	Unknown	Mixed dish	Restaurant	13	0	0	0	68	S	Case control study
Rocket salad	Vic.	Apr	2016	Norovirus	Salad	Commercial caterer	5	1	0	0	42	S	Case control study
Rockmelon	MJOI	Jul	2016	*Salmonella enterica* serotype Hvittingfoss	Primary produce	Community	144	144	13	1	6	S, M	Case control study
Imported frozen mixed berries	MJOI	Jan	2017	Hepatitis A	Primary produce	Imported food	34	10	5	0	30	M	Case series
Suspect hummus and vegetable dish	Tas.	Apr	2017	Norovirus	Mixed dish	Restaurant	32	4	2	0	39.5	S	Case control study and cohort study

Food	Jurisdiction[a]	Month[b]	Year	Organism	Category	Setting	Ill	Lab confirmed	Hospitalised	Died	Median age	Evidence[c]	Epidemiological methods
Salads	NSW	Jun	2017	Unknown	Salad	Commercial caterer	48	0	0	0	Unknown	S	Cohort study
Tuna with salad	NSW	Dec	2017	Unknown	Salad	Private residence	4	0	0	0	Unknown	CD	No formal study

a ACT: Australian Capital Territory; NSW: New South Wales; NT: Northern Territory; Qld: Queensland; SA: South Australia; Tas.: Tasmania; Vic.: Victoria; WA: Western Australia; MJOI: multi-jurisdiction outbreak investigation.

b Month in which outbreak started.

c CD: compelling descriptive evidence; S: statistical evidence; M: microbiological evidence.