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Describing Australian listeriosis outbreaks, 2012 to 2022

Sarah E Alland, Russell Stafford, Emily Fearnley, Stacey Kane, Tony Merritt, Jane McAllister, Michelle Harlock, Anthony DK Draper, Craig Shadbolt, Kirsty Hope

Australian Government
Department of Health, Disability and Ageing

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GPO Box 9848, Canberra ACT 2601

Website: **cdc.gov.au/cdi**

Email: **cdi.editor@health.gov.au**

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Abstract

Foodborne listeriosis outbreaks occur occasionally in Australia and can lead to severe outcomes for at-risk populations. Outbreaks also have the potential to cause illness in a large number of people in a short period. We identified invasive listeriosis outbreaks investigated in Australia from 2012 to 2022. We summarised the key features of these outbreaks and assessed the implications for food safety and future outbreak investigations.

Outbreak data were extracted from the national OzFoodNet Outbreak Register and described by year reported; size; severity; type of evidence; food implicated; setting in which the food was prepared and eaten; and likely cause of contamination.

Twelve listeriosis outbreaks were identified. These outbreaks involved a total of 94 cases, with 20 deaths reported (an overall case fatality rate of 21.3%). The median number of cases per outbreak was three (range: 2–34) and the median number of deaths was one (range: 0–7). Except for one outbreak with a median age of 32 years, the median age per outbreak ranged within 62–92 years. The most common food type implicated was pre-prepared composite foods (25%), including frozen meals and sandwiches. Ten outbreak investigations (83.3%) identified microbiological evidence of the same aetiological agent in the cases and the suspected food vehicle, including using whole genome sequencing as an emerging laboratory method. Most outbreaks (ten outbreaks, 83.3%) were caused by contamination of the product in the production environment, with one outbreak associated with extreme weather events.

Use of novel microbiologic techniques has increased listeriosis outbreak detection and has also improved the ability to identify causes of outbreaks. It is important that public health communication emphasises the risks of consuming high-risk ingredients in composite foods, not just as standalone products. Food safety protocols should undergo ongoing review to ensure they are responsive to a changing climate.

Keywords: *Listeria monocytogenes*; listeriosis; outbreaks; food safety; OzFoodNet; Australia

Introduction

Listeriosis is caused by the bacterium *Listeria monocytogenes* and is an important foodborne disease that can cause serious illness and death in at-risk populations. People at greater risk from listeriosis include pregnant women, their unborn and newborn babies, the elderly and other people whose immune systems have been weakened by illness or medication.[1] Listeriosis in pregnant women has been linked to miscarriage and stillbirth.[1]

Invasive listeriosis, caused by a *L. monocytogenes* infection of a normally sterile site, is a nationally notifiable disease in Australia.[2] The incidence of invasive listeriosis in Australia is low, ranging between 1.7 and 4.2 cases per million population notified per annum since 1991,[3] and cases are generally sporadic. However, listeriosis is an important condition because notified cases have a mortality rate of about 20–30 percent and foodborne listeriosis outbreaks can occur.[4,5] Outbreak investigations are complex, because this pathogen is common in the environment and certain foods are allowed to contain low levels of *L. monocytogenes* under relevant food standards.[6] Understanding the characteristics and sources of past listeriosis outbreaks can help to design appropriate public health action to prevent and minimise the impact of infection.

Systematic surveillance of foodborne outbreaks in Australia began in 2000 with the introduction of OzFoodNet, a collaborative national network for surveillance of enteric diseases.[7] Individual foodborne outbreaks are recorded in the national OzFoodNet Outbreak Register. Review of outbreaks over time can identify trends in foodborne outbreak risk factors, which can be used to inform food safety policy and advice.

We analysed listeriosis outbreaks investigated by OzFoodNet between 2012 and 2022. Our aims were to summarise the key features of the outbreaks and to assess the implications for food safety and for future outbreak investigations.

Methods

The public health response to notifications of invasive listeriosis in Australia is managed according to the Communicable Diseases Network Australia (CDNA) National Guidelines for Public Health Units.[2] Case interviews are conducted by jurisdictional public health staff, for all notified cases at the time of diagnosis, using the national OzFoodNet listeriosis case questionnaire.[8] OzFoodNet epidemiologists in each jurisdiction enter risk factor data, collected during the case interviews, into the National Enhanced Listeriosis Surveillance System (NELSS) database, which has been in place since 2010.[7] Fortnightly analysis and reporting of case isolates from all jurisdictions by a single reference laboratory has also been conducted since 2010 as part of NELSS. Initially, the laboratory methods for comparison of isolates included molecular serotype, binary type and pulse-field gel electrophoresis (PFGE), with PFGE as the definitive method to determine relatedness of isolates. From 2016 onwards, whole genome sequencing (multilocus sequence typing) with phylogenetic analysis conducted by a single reference laboratory was the definitive method used for determining relatedness between isolates.

An outbreak is defined as two or more listeriosis cases consuming a common food with epidemiological and/or microbiological evidence implicating the food as the source of illness. Outbreaks are investigated by OzFoodNet epidemiologists in collaboration with laboratory and food safety agencies. Where a suspected food source is identified, relevant jurisdictional food safety and regulatory agencies investigate the source by conducting traceback, site inspections and microbiological investigations including food product and environmental sampling. The available evidence of an association between illness and a food source can be descriptive (epidemiological case series data), analytical (epidemiological studies, including cohort and cases control studies) and/or microbiological (detection of *L. monocytogenes* in environmental and/or food isolates, including genomic comparison of these isolates with human isolates where possible).

The OzFoodNet Outbreak Register records standardised details of all foodborne and probable foodborne outbreaks investigated by OzFoodNet sites across Australia.

For this analysis, data on outbreaks with an identified aetiology of *L. monocytogenes* investigated between 1 January 2012 and 31 December 2022 were extracted from the OzFoodNet Outbreak Register on 12 April 2023. The following data fields were extracted: reporting jurisdiction; year reported; month/year onset of first and last case; geographical exposure; setting food eaten; setting food prepared; agent responsible; number of cases; number hospitalised; number died; median age; sex breakdown; evidence type; epidemiological study type; responsible vehicle; commodity category; contamination factor; and notes. All data fields were reviewed against information recorded in the 'notes' field and, where necessary, data were recoded for consistency between outbreaks using the OzFoodNet Outbreak Register Data Dictionary. The 'miscellaneous' commodity category included food items such as frozen meals and sandwiches: these were recoded as 'pre-prepared composite food'. Lead investigating OzFoodNet sites were consulted regarding missing data and were requested to provide additional context in relation to the food item implicated in the outbreak, underlying health factors of people affected by the outbreak including age, pregnancy, and immunocompromised status, and factors that contributed to the contamination.

Data cleaning and descriptive data analysis was performed using R version 4.2.3,[9] using the tidyverse[10] and janitor[11] packages. Case fatality rates were calculated as the proportion of total cases who died during the outbreak. Outbreaks were summarised by year reported, size, severity, type of evidence, food implicated, the setting(s) in which the food was prepared and eaten, likely cause of contamination and *L. monocytogenes* subtype (detected in clinical, food and/or environmental isolates from the outbreak). The setting in which the food was prepared is also known as the production environment and refers to any setting where a food was produced or prepared before being provided to the consumer, such as a farm, factory or kitchen.

Our study was approved by the Australian National University Human Research Ethics Committee (2023/157).

Results

Outbreaks summary

There were 12 listeriosis outbreaks identified and investigated by OzFoodNet in the study period (Table 1). These outbreaks involved a total of 94 cases, with 20 deaths reported, corresponding to an overall case fatality rate of 21.3%. The median number of cases per outbreak was three (range: 2–34 cases) and the median number of deaths was one (range: 0–7 deaths). Half of all outbreaks (six) involved cases who resided across multiple jurisdictions. Three outbreaks involved internationally traded products, with two of these outbreaks having cases reported internationally (noting that the numbers of international cases were not recorded in the total number of cases per outbreak).

The median age of cases in one outbreak was 32 years (two out of three cases were perinatal cases); otherwise the median age of cases per outbreak was in the range 62–92 years. There were six perinatal cases reported across three outbreaks, with half resulting in adverse events for the pregnancy (two miscarriages and one pre-term birth).

Table 1: Summary of listeriosis outbreaks, Australia, 2012–2022

ID[a]	Year	Jurisdictions reporting cases[b]	Cases (No.)[c]	Deaths (No.(%))	Food implicated	Setting food eaten	Cause of contamination	Contributing factors	Level of evidence	*L. monocytogenes* subtype[d,e]
1	2012	ACT, NSW, Qld, Tas., Vic., WA	34	6 (17.6)	Pasteurised brie and/or camembert cheese	Community	Ingestion of ready-to-eat products contaminated in the production environment	Possible contamination during movement of products through production facility on trolleys	Analytical + Microbiological	Serotype 4b,4d,4e; Binary type 254/255; PFGE type 119A:44A:1
2	2012	NSW, Vic.	3	1 (33.3)	Suspected smoked salmon	Community	Ingestion of ready-to-eat products but unknown source of contamination – product unable to be traced	No kill step in cold smoked salmon production. High-risk food consumed by high-risk groups	Analytical	Serotype 1/2a,3a; Binary type 58; PFGE type 18A:17A:10
3	2013	WA	3	0 (0)	Frozen meals	Community	Unknown	Meals assembled from in-house and externally sourced components, and therefore source of contamination difficult to determine	Microbiological	Serotype 1/2a, 3a; Binary type 59; PFGE type 153:153:117; MLVA 04-16-15-00-03-08-10-00-00
4	2013	NSW	3	1 (33.3)	Profiteroles	Hospital	Ingestion of ready-to-eat products contaminated in the production environment	Product supplied to hospital with cases having significant underlying health conditions	Microbiological	Serotype 1/2b,3b,7; Binary type 233; PFGE type 4A:4:1; MLVA 04-17-16-05-03-11-14-00-16
5	2014	NSW	3	1 (33.3)	Sandwiches	Healthcare – non-hospital	Products contaminated in the production environment	Product was supplied to cancer treatment facility by single supplier. Cases consumed different types of sandwiches, but outbreak strain was detected in component foods in the production environment	Microbiological	Serotype 1/2b,3b,7; Binary type 158; PFGE type 4:4:5A; MLVA 04-17-16-05-03-11-14-00-16

ID[a]	Year	Jurisdictions reporting cases[b]	Cases (No.)[c]	Deaths (No.(%))	Food implicated	Setting food eaten	Cause of contamination	Contributing factors	Level of evidence	*L. monocytogenes* subtype[d,e]
6	2016	NSW, Qld, SA, Vic.	8	0 (0)	Deli items	Community	Ingestion of contaminated ready-to-eat products contaminated in the production environment & Cross contamination from ready-to-eat ingredients at retailer	Deli product contaminated in production environment was found to have cross-contaminated other deli products at point of retail sale	Microbiological	Binary type 83; MLVA 04-20-19-04-03-11-10-04-00; MLST 9
7	2017	Qld	3	0 (0)	Unknown	Hospital	Inadequate cleaning of equipment in the production environment	No common food source identified but outbreak strain detected in cases was found in environmental samples collected in the hospital kitchen	Descriptive	Binary type 159; MLVA 04-17-16-05-03-11-14-00-16; MLST 3
8	2018	SA	3	0 (0)	Ready to eat meals	Community	Products contaminated in the production environment	Likely due to meals not having a kill step or post cook contamination during packing. Meals were supplied to a high-risk age group	Microbiological	Binary type 159; MLST 3
9	2018	NSW, Qld, Tas., Vic., international	22	7 (31.8)	Rockmelon	Community	Ingestion of raw products contaminated in the production environment	Contamination was likely caused by heavy rainfall followed by dust storms increasing the organic load on the product	Analytical + Microbiological	Serotype pattern 4b, 4d, 4e variant; Binary type 159; MLST 240
10	2019	NSW, Qld, Vic.	4	2 (50)	Smoked salmon	Community	Ingestion of ready-to-eat products contaminated in the production environment	No kill step in cold smoked salmon production. High-risk food consumed by high-risk groups	Analytical + Microbiological	Serotype 1/2a,3a; MLST 120

ID[a]	Year	Jurisdictions reporting cases[b]	Cases (No.)[c]	Deaths (No.(%))	Food implicated	Setting food eaten	Cause of contamination	Contributing factors	Level of evidence	*L. monocytogenes* subtype[d,e]
11	2020	NSW, Qld, SA, international	6	0 (0)	Imported enoki mushrooms	Community	Ingestion of raw products contaminated in the production environment	International outbreak with cases in multiple countries identified. Contaminated product was imported to Australia	Microbiological	Serotype 1/21,31; Binary type 59; MLST 7
12	2022	Vic.	2	2 (100)	Pre-prepared sandwiches	Hospital	Inadequate cleaning of equipment in the production environment	Widespread colonisation in the production environment. Products primarily produced for the healthcare industry	Microbiological	Serotype 1/2b, 3b, 7; Binary type 159; MLST 3

a ID: outbreak number.

b ACT: Australian Capital Territory; NSW: New South Wales; Qld: Queensland; SA: South Australia; Tas.: Tasmania; Vic.: Victoria; WA: Western Australia.

c Australian cases only; overseas case numbers are not recorded in the OzFoodNet Outbreak Register.

d The subtype is the characterisation of the organism detected in outbreak specimens, which may be clinical, food and/or environmental. The results of all typing methods performed are reported.

e PFGE: pulse-field gel electrophoresis; MLVA: multiple locus variable-number tandem repeat analysis; MLST: multilocus sequence type.

Foods implicated

The implicated food types varied across outbreaks (Figure 1). The most common food type recorded was pre-prepared composite foods, implicated in four outbreaks; this category included items such as frozen meals and sandwiches that contain multiple food items in a pre-prepared meal. Fresh produce (fresh or processed fruit or vegetables) and seafood were each implicated in two outbreaks. The food product responsible could not be determined for one outbreak.

Level of evidence

Ten of the twelve outbreaks (83.3%) used microbiological evidence in the outbreak investigation (Table 1). In three of these outbreaks, microbiological evidence was used in combination with analytical evidence. In all ten of these outbreaks, the likely food source was able to be confirmed through the identification of common genomic strains between human cases and food or environmental samples. The remaining two outbreaks used analytical and descriptive evidence respectively, with the likely food source only able to be identified for the outbreak with analytical evidence.

Outbreak settings

Eight of the twelve outbreaks (66.7%) involved a widely distributed commercial product eaten in a community setting; four outbreaks (33.3%) involved food eaten in a hospital or healthcare setting. Although outbreaks in hospitals or healthcare settings were rare and involved a small number of cases, the case fatality rate was higher in these settings than in community outbreaks (36.4% compared to 19.3%).

Commercially manufactured foods were responsible for more than half the outbreaks (seven outbreaks or 58.3%) (Figure 2). Outbreak 1, which involved a widely distributed commercially manufactured product that was also exported overseas, was the largest outbreak. Primary production outbreaks had a higher median number of cases than did all other types of food preparation settings (median of 14 cases compared to three cases). In addition, both of the primary production outbreaks included international cases. Outbreak 11 was part of a large international outbreak of Enoki mushrooms that had been imported to Australia from South Korea.[12]

Figure 1: Listeriosis outbreaks by commodity category implicated and year reported, Australia, 2012–2022

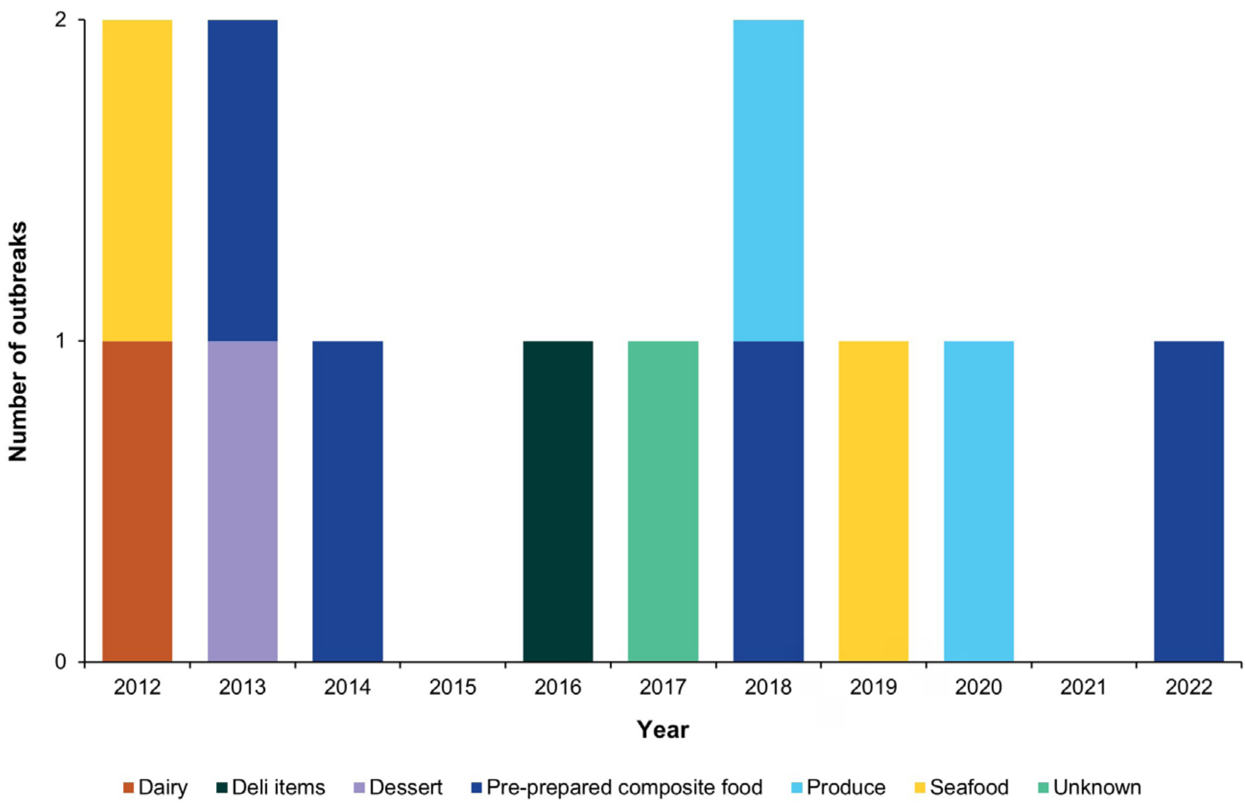
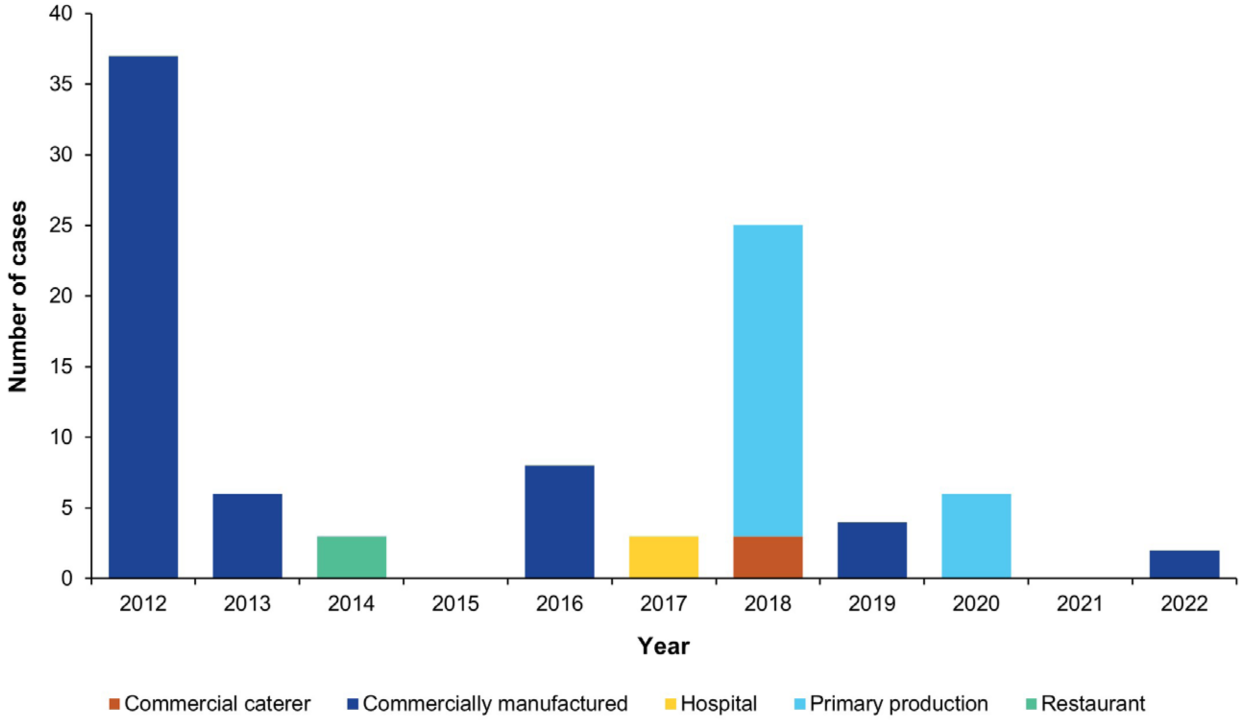


Figure 2: Listeriosis outbreaks by number of cases, setting prepared and year reported, Australia, 2012–2022



Contamination sources

Ten of the twelve outbreaks (83.3%) were caused by contamination of the product in the production environment, with varying reasons for this contamination (Table 1). Seven outbreaks (58.3%) involved the consumption of ready-to-eat products, which would not have had a suitable kill step in production. In two outbreaks (16.7%), inadequate cleaning of the equipment was found to be the cause of contamination. One outbreak (8.3%) was associated with extreme weather events.

Discussion

This is the first summary of listeriosis outbreaks in Australia since a previous analysis was published summarising outbreaks that occurred between 2001 and 2010.[5] The present analysis shows that the number of listeriosis outbreaks investigated by OzFoodNet in Australia increased from five outbreaks during 2001–2010 to twelve outbreaks in the current study period (2012–2022). The overall case fatality rate of outbreaks remained consistent across the previous analysis and the current study period, at around 22%. Outbreak cases continue to be generally from known at-risk population groups (older people, and pregnant women and their unborn children), with high risk of adverse health outcomes for these cases. Contributing factors for outbreaks were identified as consumption of high-risk products by susceptible consumers, contaminated production environments, and environmental conditions.

Outbreak detection

Although the number of outbreaks increased in the study period compared to the previous analysis of Australian outbreaks, the median size of the outbreaks decreased by 50% from six cases in the previous analysis[5] to three cases in this analysis. Listeriosis case notification rates remained stable in Australia over both periods.[3] The increase in the number of outbreaks is consistent with international trends that show an increase in listeriosis outbreaks reported worldwide in recent years.[13–15] Laboratory methods used for the investigation of listeriosis have changed considerably with the introduction and development of whole genome sequencing; international evidence suggests that the new methods have improved sensitivity to detect outbreaks.[16] Improved outbreak detection may also explain the increase in identified Australian outbreaks, with whole genome sequencing being employed in Australia since 2016, as well as the introduction of the National Enhanced Listeriosis Surveillance System by OzFoodNet in 2010 to provide formalised arrangements to compare epidemiological and laboratory case data between state and territory jurisdictions.[7]

At-risk groups

The characteristics of cases in outbreaks included in this study are consistent with what is known about people at risk for listeriosis. Generally, the cases identified in the outbreaks were older or were pregnant women. The overall case fatality rate was consistent with literature.[4,5] A higher case fatality rate observed in outbreaks in healthcare settings likely reflects increased vulnerability from underlying conditions in the population affected.

L. monocytogenes is common in the environment but usually only causes severe illness when present in food consumed by at-risk groups.[17] Consumption of food with high levels of *L. monocytogenes* is required to cause illness in the general population.[18] As such, Food Standards Australia New Zealand (FSANZ), the government agency responsible for setting food standards in Australia and New Zealand, adopts a risk-based approach with mandatory microbiological limits for *L. monocytogenes* in ready-to-eat foods.[19] Ready-to-eat foods implicated in outbreaks in this study, such as smoked salmon, are permitted to contain *L. monocytogenes* not exceeding 100 cfu/g.[19] Even so, these foods continue to present a risk when consumed by vulnerable populations. Health authorities should continue to provide targeted advice to at-risk groups to reinforce the risks of consuming foods likely to contain *L. monocytogenes*.

Setting

Australia has comprehensive standards governing food safety in settings where food is served to vulnerable people. Standard 3.3.1 of the FSANZ Food Standards Code requires these settings, including hospitals, to implement a food safety program for control of hazards relating to food service.[20] Despite this, outbreaks were detected in healthcare settings in the study period, highlighting that the risks associated with *L. monocytogenes* contamination cannot be eliminated entirely. It is important that food safety authorities continue to monitor the application of the Food Standards Code in healthcare settings and to undertake continuous improvement to ensure that risks associated with food service to vulnerable people can be mitigated.

Foods implicated

Listeriosis has been associated with contamination of certain pre-prepared ready-to-eat foods, such as deli meats, soft cheese, chilled seafood and raw fresh produce.[21] Food safety and public health messaging generally focuses on communicating the risks associated with consuming these foods in isolation. However, it is notable that in four outbreaks, composite products were identified as the food source with contaminated high-risk foods used in some of these products, such as salad ingredients included in pre-prepared sandwiches. The focus on individual ingredients in risk communication may be confusing for consumers and might lead them to underestimate the risk of consuming composite products that contain high-risk ingredients. Food safety and public health authorities should ensure that risk communication messaging encourages consumers to consider all components of food products, not only individual products in isolation.

Contamination of the production environment

Of the outbreaks in this study for which the likely food source was identified, all involved the consumption of raw or ready-to-eat products. Because these products are not further cooked before consumption, they do not have a step that could kill *L. monocytogenes*. Safe handling of these products in the production environment and food chain is essential to limit the risk of infection. In nine outbreaks, contamination was found in the production environment, which is commonly reported as a contamination factor in listeriosis outbreaks internationally.[22–24]

Ensuring compliance with food safety standards in the production environment, and ongoing review of these standards, should be a priority for industry and food safety regulators.

The smoked salmon industry provides an example of improvements to food safety standards, made as a result of lessons learned from a listeriosis outbreak. After the smoked salmon outbreak in 2019 (Outbreak 10), which involved a product that originated in Tasmania, the Tasmanian Department of Primary Industries, Parks, Water and Environment developed *Guidelines for the Safe Manufacture of Smoked Fish*, in consultation with industry, to increase the standards around the production of smoked fish products, including a recommendation to add an acidity regulator to inhibit the growth of *L. monocytogenes*.[25]

Climate change – an emerging risk

It is widely acknowledged that extreme weather events can disrupt food production, but these events also have the potential to impact food safety.[26] The 2018 outbreak involving rockmelon (Outbreak 9) demonstrates the food safety risks associated with extreme weather in primary production regions. *L. monocytogenes* has been shown to grow and survive on intact produce after harvesting, but with appropriate handling practices this can be managed.[27] The producer of the implicated product had hygiene and sanitation practices that were on par with, if not better than, similar producers across Australia. However, the combination of rain and dust in the region prior to harvest likely increased the organic load on the product and meant that the usual practices were not effective.

Since the rockmelon outbreak occurred, FSANZ has updated the Food Standards Code to require melon producers to manage the food safety risks associated with weather events.[20] FSANZ also provides best-practice advice to producers on managing the food safety risks associated with weather events, including taking action to prevent contact with contaminated water and dust, and removing, treating or diverting produce damaged by extreme weather.[28]

Extreme weather events, as occurred in the rockmelon outbreak, are just one example of how climate change impacts food safety. For example, other recent events have shown how increasing sea temperatures in southern and southeastern Australia have supported the growth of bacteria and the spread of marine biotoxins in seafood harvesting areas, leading to human illness from the consumption of contaminated seafood.[29,30] Food safety risks will need to continue to be managed in the future as the climate continues to change.[26]

Limitations

The data analysed in this study represents reported outbreaks of invasive listeriosis investigated by OzFoodNet. Outbreaks may not be detected due to an absence of sufficient epidemiological or microbiological evidence indicating a link between notified cases. Study findings could be affected if there were undetected outbreaks that had different characteristics compared to those investigated. However, the findings of this study, that suggest improved outbreak detection in the study period with smaller case numbers per outbreak, provides assurance that most outbreaks were likely detected.

Standardised data recorded in the OzFoodNet Outbreak Register provided limited context for the outbreaks investigated. Additional data was requested from OzFoodNet outbreak lead jurisdictions to provide more nuanced context for the data and to enable more meaningful analysis.

The analysis conducted was descriptive only and did not make any assessment of causality or statistical associations. However, the analysis does provide an understanding of common themes emerging from investigated outbreaks to inform future public health response.

Conclusion and recommendations

Outbreaks of listeriosis can have severe outcomes for at-risk populations; outbreaks also have the potential to spread across geographical regions when associated with widely distributed produce or commercially manufactured foods. Our review of listeriosis outbreaks investigated by OzFoodNet in Australia between 2012 and 2022 suggests that improvements in surveillance in recent years have enhanced listeriosis outbreak detection and have made it easier to identify the likely cause of outbreaks. However, challenges remain that require further consideration and action.

At-risk groups continue to be affected by listeriosis outbreaks through consumption of high-risk foods in both community and healthcare settings, reinforcing the importance of ongoing targeted public health communication to these groups.

The implication of composite products as a common outbreak source suggests that public health communication needs to emphasise the risks associated with consuming high-risk foods as components of meals, not solely as individual products, especially for at-risk groups. Climate change is expected to increase the frequency and severity of extreme weather events in the future. Environment and food safety authorities should review expected processes for primary producers to ensure that food safety remains robust in the face of the changing climate.

Investigation of listeriosis outbreaks, and analysis of systematic themes that emerge from outbreaks over time, are important to assist authorities and industry to implement measures to prevent future outbreaks and should continue to be supported.

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Author details

Sarah E Alland,[1,2,3]

Russell Stafford,[4]

Emily Fearnley,[5]

Stacey Kane,[6]

Tony Merritt,[2]

Jane McAllister,[7]

Michelle Harlock,[8]

Anthony DK Draper,[1,9,10]

Craig Shadbolt,[11]

Kirsty Hope[3]

1. National Centre for Epidemiology and Population Health, College of Law, Governance and Policy, Australian National University, Canberra
2. Health Protection Service, Hunter New England Local Health District, Newcastle
3. Health Protection NSW, New South Wales Ministry of Health, Sydney
4. Queensland Department of Health, Brisbane
5. South Australian Department for Health and Wellbeing, Adelaide
6. Australian Government Department of Health, Disability and Ageing, Canberra
7. Victorian Department of Health, Melbourne
8. Tasmanian Department of Health, Hobart
9. Northern Territory Centre for Disease Control, Public Health Division, NT Health, Darwin
10. Global and Tropical Health Division, Menzies School of Health Research, Charles Darwin University, Darwin
11. NSW Food Authority, Sydney

Corresponding author

Sarah Alland

Address: Health Protection NSW,
1 Reserve Road, St Leonards NSW 2065

Phone: +61 422 817 919

Email: sarah.alland@health.nsw.gov.au

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