Applied Epidemiology in Communicable Diseases, Victoria, 2016 - 2017

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Originality statement

'I hereby declare that this submission is my own work and that to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at the ANU or any other educational institution, except where due acknowledgement is made in the text. Any contribution to the research by others, with whom I have worked at the Microbiological Diagnostic Unit Public Health Laboratory or the Victorian Government Department of Health and Human Services or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation or linguistic expression is acknowledged.'

Siobhán Clare St George

11 February 2018

"MAE ANU" at the 9th TEPHINET Global Conference in Chiang Mai, Thailand, August 2017. MAE 2016/2017 dorks left to right: Julie Collins, Siobhan St George, Mica Hartley, Katherine Todd, and Laura Edwards.

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Abbreviations

AGAR	Australian Group on Antimicrobial Resistance
AGE	Acute gastroenteritis
AMR	Antimicrobial resistance
APAS	Australian passive antimicrobial resistance surveillance
BSI	Bloodstream infection
CARAlert	National Alert System for Critical Antimicrobial Resistances
CATI	computer-assisted telephone interviewing
CDC	United States' Centres for Disease Control and Prevention
CDCC	Communicable Diseases Control Conference
CDCP	Communicable Disease Prevention and Control
CDES	Communicable Disease Epidemiology and Surveillance
CDS	Calibrated Dichotomous Sensitivity test method
CI	Confidence interval
CLSI	Clinical and Laboratory Standards Institute
CPE	Carbapenemase-producing Enterobacteriaceae
CSF	Cerebrospinal fluid
CVO	Chief Veterinary Officer
DANMAP	Danish Integrated Antimicrobial Resistance Monitoring and Research Program
DEDJTR	Department of Economic Development, Jobs, Transport and Resources
DHHS	Victorian Government Department of Health and Human Services
DNA	Deoxyribonucleic acid
DOB	Date of birth
DPHO	Divisional public health officer
EARS-Net	European Antimicrobial Resistance Surveillance Network

EHO	Environmental health officer
EIPDSWG	Enhanced Invasive Pneumococcal Diseases Surveillance Working Group
EUCAST	European Committee on Antimicrobial Sensitivity Testing
FDA	United States Food and Drug Administration
FEOR	Food, Environment, and Outbreak Response
FSU	Food Safety Unit
GOOA	Gastrointestinal outbreak onsite assessment
GP	General Practitioner
HREC	Human Research Ethics Committee
HUS	Haemolytic Uraemic Syndrome
IBD	Inflammatory bowel disease
IBS	Irritable bowel syndrome
ID	Identification
IQR	Interquartile range
IT	Information technology
KPI	Key Performance Indicator
LIMS	Laboratory information management system
MAE	Master of Philosophy - Applied Epidemiology
MDR	Multi-drug resistant
MDU PHL	Microbiological Diagnostic Unit Public Health Laboratory
MDU	Microbiological Diagnostic Unit Public Health Laboratory
MIC	Minimal inhibitory concentration
MLVA	Multiple Locus Variable-number Tandem Repeat Analysis
MRSA	Methicillin-resistant Staphylococcus aureus
NEPSS	National Enteric Pathogens Surveillance System
NNDSS	National Notifiable Diseases Surveillance System

NNN	National Neisseria Network
OFN	OzFoodNet
PCR	Polymerase chain reaction
PHESS	Public Health Event Surveillance System
PHO	Public health officer
PI-IBS	Post-infectious irritable bowel syndrome
PPV	Positive predictive value
RDD	Random digit dialling
ReA	Reactive arthritis
RFI	Request for information
RR	Risk ratio
SPHO	Senior Public Health Officer
STEC	Shiga-toxin producing *Escherichia coli*
TEPHINET	Training Programs in Epidemiology and Public Health Interventions Network
UR	Unit record
VFFS	Victorian Food Frequency Survey
VHPPS	Victorian Hospital Pathogen Surveillance System
VICNISS	Victorian Hospital Acquired Infection Surveillance System
VIDB	Victorian Infectious Diseases Bulletin
VIDRL	Victorian Infectious Diseases Reference Laboratory
VPHS	Victorian Population Health Survey
VRE	Vancomycin Resistant Enterococci
WHO	World Health Organisation

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Abstract

This thesis presents the projects and activities I have undertaken throughout 2016-2017 to fulfil the requirements of the Master of Philosophy - Applied Epidemiology (MAE). My placement was shared between OzFoodNet Victoria (within the Victorian Department of Health and Human Services) and the Microbiological Diagnostic Unit Public Health Laboratory (MDU). This shared placement provided me with the unique opportunity to experience the different day-to-day workings of a state health department and a public health reference laboratory, while also experiencing the multitude of ways in which these two organisations work together to protect the health of the Victorian public.

In my placement at MDU I completed an evaluation of the Victorian Hospital Pathogens Surveillance Scheme (VHPSS). This scheme has been running since 1988 and collects information on invasive bacterial and fungal infections and their antimicrobial sensitivities in the Victorian population. My evaluation highlighted the value of the VHPSS in collecting information on pathogens not captured by any other surveillance system in Victoria, and made a number of recommendations to improve the function and focus of the scheme, especially in the context of increasing concerns surrounding antimicrobial resistance nationally and globally.

In my placement with OzFoodNet Victoria I was involved in the investigation of multiple clusters and outbreaks of enteric disease. In particular, I coordinated the investigation of an outbreak of *Salmonella* Typhimurium at a Melbourne café which was linked to the consumption of hollandaise sauce. This outbreak highlighted the dangers of improper food handling in preparing and storing partially-cooked egg products, and the limited knowledge many people have about the risks of consuming these foods.

Following another *Salmonella* outbreak, I conducted an epidemiological study on the proportion of outbreak cases who developed symptoms of transient or chronic sequelae following their infection. In particular, this study collected information on symptoms of post-infectious irritable bowel syndrome (PI-IBS) and reactive arthritis (ReA). This study found that in the six months following their *Salmonella* infection, 18% of study participants experienced new gastrointestinal symptoms consistent with PI-IBS, and 11% of participants experienced new joint symptoms consistent with ReA. Many of

these participants were still experiencing these symptoms a year after their *Salmonella* infection, indicating the development of chronic disease.

I also conducted analyses on data from the Victorian Food Frequency Survey. This survey collected information on the consumption of approximately 250 food items in 4008 well Victorian people, so that their food consumption frequencies could be compared to information from *Salmonella* case interviews (and interviews for cases of other enteric pathogens such as *Campylobacter* and Shiga-toxin producing *Escherichia coli*) to assist in generating hypotheses to try and identify sources of infection. I translated this data into an accessible format for use in outbreak investigations, and examined the demographic consumption patterns of various high-risk food items to determine who might be most at risk of infection.

These projects, alongside the teaching activities and scientific communications presented in this thesis, fulfil the requirements of the MAE program and will contribute to the public health of Victorians.

Chapter I:

Summary of Field Experience and Core Competencies

Field Placements at the Microbiological Diagnostic Unit Public Health Laboratory and OzFoodNet Victoria

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Field placements

My Master of Philosophy - Applied Epidemiology (MAE) field placement was a split placement shared between OzFoodNet Victoria at the Victorian Department of Health and Human Services (DHHS), and the Microbiological Diagnostic Unit Public Health Laboratory (MDU-PHL, or MDU for short). I worked across both institutions concurrently, spending three days a week at one organisation and two days a week at the other, with the allocation of days depending on the staffing needs of each organisation and the projects being undertaken. This shared placement allowed me to experience the multitude of ways in which these two organisations work closely together, while also providing me with a greater understanding of the different challenges and demands they face as separate public health entities.

OzFoodNet Victoria

My placement at the Victorian DHHS was funded by OzFoodNet Victoria, and sat within the Communicable Disease Epidemiology and Surveillance (CDES) section of the Health Protection Branch. As the name suggests, the CDES section is responsible for the surveillance of communicable diseases in Victoria and all related epidemiological functions, including (but not by any means limited to) receiving and reviewing communicable disease notifications, investigating clusters and outbreaks of disease, and analysing and reporting on communicable disease surveillance data for the development and evaluation of public health policy. Within this section, different epidemiologists are responsible for the oversight of different disease groupings. Foodborne and enteric communicable diseases are the domain of OzFoodNet Victoria.

Established in 2000 by the Australian Government Department of Health and Ageing, OzFoodNet is a network of epidemiologists in each state and territory health department who work collaboratively to facilitate integrated country-wide surveillance, outbreak investigation, and control of foodborne diseases in Australia. Joy Gregory is the principal OzFoodNet epidemiologist in Victoria, and has worked with OzFoodNet since it was first established. I was lucky enough to have Joy as my field supervisor, and throughout my placement I abided by the wise words of a previous MAE scholar: “When Joy Gregory talks, you listen!”.

My placement with OzFoodNet gave me extensive experience in the surveillance, investigation, and epidemiology of foodborne and enteric disease in Victoria. Apart from the three core MAE projects that I completed with OzFoodNet (detailed in chapters II-IV of this volume), throughout my placement I was involved in many of the day-to-day functions of the unit, including:

- Daily sign-off and assessment of foodborne and enteric disease notifications for follow-up;
- Weekly reporting of foodborne and enteric disease surveillance data ;
- Monitoring of surveillance data for clusters and outbreaks;
- Attendance at and contribution to regular OzFoodNet teleconferences and face-to-face meetings;
- Preparation of Victorian situation reports during multi-jurisdictional outbreak investigations;
- Contributing to the 2015 OzFoodNet Victoria Annual Report; and
- Contributing to the investigation of multiple clusters and outbreaks of foodborne and enteric disease, including questionnaire development and production, case interviews, and providing situation updates and reports

Thanks to my placement with Joy and OzFoodNet, foodborne and enteric diseases will always be my first epidemiological love, and I hope to have the opportunity to work further in this field in the future.

Microbiological Diagnostic Unit Public Health Laboratory

MDU was established in 1897, making it one of the oldest public health laboratories in the world, and the longest continually serving public health laboratory in Australia. Although MDU sits within the University Of Melbourne School Of Biomedical Sciences, it is funded predominantly by the Victorian DHHS to provide a comprehensive microbiology service for the investigation of infectious disease and food and waterborne outbreaks in Victoria. In 2014, MDU moved into the Peter Doherty Institute for Infection and Immunity, a joint venture between the University of Melbourne and the Royal Melbourne Hospital. It soon became home to Doherty Applied Microbial Genomics, which has been funded to facilitate research and

leadership in public health microbial genomics and clinical microbiology practice. MDU is also the World Health Organisation (WHO) Regional Reference Laboratory for Invasive Bacterial Vaccine-Preventable Diseases.

MDU is directed by Professor Benjamin Howden, and Dr Deborah Williamson is the deputy director and head of epidemiology. Working with MDU's epidemiology section, I was privileged to be co-supervised by both Prof. Howden and Dr Williamson throughout my placement. My placement at MDU allowed me to become familiar with the extensive range of projects the epidemiology section coordinates and is involved in, including:

- Coordination of multiple surveillance systems, including Victoria's Carbapenemase-producing Enterobacteriaceae (CPE) surveillance and response unit (VCRSU), the National Enteric Pathogens Surveillance System (NEPSS), and the Victorian Hospital Pathogen Surveillance Scheme (VHPSS);
- Contribution to multiple national surveillance systems, including meningococcal and invasive pneumococcal disease, and animal health surveillance;
- Regular surveillance reporting to state and national stakeholders;
- CPE outbreak and cluster investigation, co-ordination and management;
- Epidemiological support to the Victorian DHHS and Australian Government Department of Health for outbreaks of foodborne, enteric and bacterial diseases;
- Coordination of multiple projects relating to MDU's role as the World Health organisation (WHO) Regional Reference Laboratory; and
- Data management and response to routine and *ad-hoc* requests for information and data

In addition, the MDU epidemiology team contribute to a number of projects relating to antimicrobial resistance and whole genome sequencing, and are a key point of contact for the Victorian DHHS and other stakeholders. My placement with MDU has also provided me with the opportunity to attend many seminars and symposiums on topics such as whole genome sequencing in public health and challenges in addressing antimicrobial resistance in Australia and internationally. Given the increasing involvement of these issues across all areas of communicable disease epidemiology, I

am grateful for the range of opportunities I have had to increase my understanding of these concepts.

Throughout my placement at MDU I was very lucky to be given the time to work on my evaluation of the VHPSS (chapter V) without taking on additional duties, but when one of the epidemiology team departed MDU, my experience with the work of the section allowed me to take on a part-time position to support the epidemiology team. I am delighted to be continuing in this role following my MAE, and look forward to contributing to the varied and exciting work of the MDU epidemiology section.

Core competencies

Table 1 summarises my completion of the core competencies for the MAE program, and the chapters and appendices in which they are detailed.

Table 1: Summary of MAE projects presented in this thesis and the core MAE competencies and course requirements they fulfil

Volume Chapters	Core Competencies and Course Requirements							
	Data analysis	Outbreak Investigation	Epidemio-logical study	Evaluation of a surveillance system	Conference presentation	Late draft of an article for publication	Communication to a lay audience	Teaching activities
Chapter II: An outbreak of *Salmonella* Typhimurium associated with hollandaise sauce	✓	✓				✓		
Chapter III: Irritable bowel syndrome and reactive arthritis following an outbreak of *Salmonella* Anatum	✓		✓		✓		✓	
Chapter IV: Analysis of the Victorian Food Frequency Survey (VFFS), 2014-2016	✓							
Chapter V: Evaluation of the Victorian Hospital Pathogen Surveillance System (VHPSS)	✓			✓				
Appendix A: Teaching activities								✓

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Chapter II:

Investigation of an Acute Public Health Problem

An outbreak of *Salmonella* Typhimurium associated with hollandaise sauce

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Preface

Background to project

This chapter describes an outbreak investigation initiated in December 2016 in response to a notification to the Victorian Department of Health and Human Services (DHHS) Communicable Disease Prevention and Control unit (CDCP). CDCP was notified of complaints of illness received by a Melbourne metropolitan council from customers of a café who had become unwell after eating a seafood eggs benedict menu item. As a café-based outbreak with multiple initial complaints, this incident was identified as a promising opportunity for me to fulfil the MAE core requirement to investigate an outbreak or an acute public health event. I immediately became involved in the outbreak investigation, working to determine the extent of the outbreak; to characterise the outbreak by person, place, pathogen, and time; to determine the most likely source of the reported illness; and to implement targeted public health interventions to eliminate the risk to public health and prevent further illness.

My role

I was the co-lead investigator for this outbreak investigation, working with Senior Public Health Officer (SPHO) Kaye Sturge of the CDPC unit. Kaye was the initial point of contact for the local council and continued to coordinate and liaise with the council Environmental Health Officers (EHOs) throughout the investigation. My role in the outbreak investigation included:

- Interviewing initial complainants with the standard DHHS Gastroenteritis Outbreak case questionnaire, including collecting contact information for other diners
- Developing a menu-based questionnaire
- Interviewing further complainants and their dining partners, and re-interviewing initial complainants, with the menu-based questionnaire
- Responding to case enquiries
- Managing a line list including the details of dining parties, interview status, sample collection date, and laboratory results

- Active case finding through the monitoring of MLVA results
- Compiling outbreak situation reports where required
- Entering case data into the DHHS Public Health Event Surveillance System (PHESS)
- Completing descriptive and analytic data analyses
- Drafting the outbreak report

Lessons learnt

This was the first outbreak investigation I had been involved in where the source of infection was clearly identified by cases from the start of the investigation. This was a new experience for me and provided some unique lessons, especially in regards to communicating with cases. Of the many lessons I learnt undertaking this investigation, some of the most significant were:

- **The immense value of experienced and 'on the ball' EHOs and PHOs**: In this investigation, the initial processes provided by the café to the EHO for making the hollandaise sauce specified that it was kept in the fridge after production. The DHHS PHO immediately realised this must be incorrect as she was aware that cooling a hollandaise sauce would solidify it. Consequently, the EHO returned to the café and was given a second, more accurate process description. The PHO's experience, vast knowledge of foodborne disease, and eye for detail resulted in the identification of a number of food handling issues not originally disclosed to the EHO, which may not have been discovered, or discovered as quickly, if the PHO had not noticed these discrepancies. This situation highlighted for me the importance of having an awareness of the high-risk foods for *Salmonella* infection, the processes used to make them, and their common contamination pathways when conducting environmental and epidemiological investigations. I am lucky to have had the opportunity to learn from such knowledgeable and experienced PHOs during my time here.
- **How to speak to cases about an outbreak**: This outbreak tested my skills in 'walking the line' between providing information and education to cases and disclosing restricted information about the outbreak. Unsurprisingly, cases

wanted to know what had caused their illness and how many others had been affected. Although unable to provide any detailed information about an ongoing investigation, I regarded these questions as a fantastic opportunity to increase knowledge about *Salmonella* and the dangers of high risk foods in the very people who ate them. Given that most cases strongly suspected one particular meal as the cause of their infection, I could hypothetically explain the different pathways by which it might have become contaminated, though I was careful to make sure the people I spoke to knew these were possibilities and not facts about the investigation. This developed my skills in communicating complicated disease processes to a lay (though very interested) audience. I found that people really appreciated the information I gave them, especially as the café had provided very little information to affected customers. This experience prompted part of my teaching exercise for the first year MAE students, where I provided a basic outline of what one can and can't say during an outbreak investigation (Thesis Appendix 1).

- **The importance of MLVA in *Salmonella* surveillance**: As the café involved in this outbreak didn't routinely take bookings, we were initially reliant on finding cases through complaints to the café and the local council, and quite a number of these cases had not submitted faecal samples when we spoke with them. Fortunately, once an MLVA pattern for cases was established, we could employ active case finding to identify further confirmed cases through the notifiable disease surveillance system (PHESS). However, this process highlighted for me the difficulties in determining the extent of an outbreak without a booking list, and the issues this presents when trying to conduct an analytic study.

- **The influence of social context on an outbreak:** Many of the cases in this outbreak became unwell after sharing or trying a portion of the eggs benedict meal with seafood that a dining partner (usually a friend or family member) had ordered, resulting in large case numbers relative to portions served. The large group included in the cohort study, however, was a group of colleagues attending a work breakfast. No-one in this group shared meals or tried a colleague's food, so only those who ordered the meal became unwell. This was, on a small scale, an interesting insight into how the social context of an event

might influence the transmission and/or number of cases in an outbreak. It also highlighted the importance of asking cases about any other foods they may have tasted or eaten in addition to the meals they ordered and ate.

Public health impact

This outbreak investigation succeeded in ending the outbreak and limiting the risk of future illness from this café by:

- Identifying the source of illness;
- Preventing the further spread of illness by removing the menu item from sale;
- Reducing the risk of further outbreaks from this premises by instigating the permanent removal of the eggs benedict dish from the menu; prompting the use of pasteurised egg products by the premises; instituting effective cleaning processes; and amending issues in food handling procedures; and
- Identifying and providing recommendations to improve sanitation, hygiene, and quality assurance measures at the supplying egg farm

This outbreak investigation also gave us an opportunity to provide both the food establishment and affected customers with a greater knowledge and understanding of *Salmonella* transmission, risk factors, and infection prevention. More broadly, we hope that documentation of this outbreak investigation will contribute to the evidence base on the burden of *Salmonella* infection and egg-associated outbreaks in Victoria.

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Staff of both the Communicable Disease Epidemiology and Surveillance (CDES) and Communicable Disease Prevention and Control (CDPC) units contributed enormously to this work. I would primarily like to thank senior CDPC PHO Kaye Sturge for allowing me to co-investigate this outbreak with her, for bestowing on me her organisational teachings, and for her vast knowledge, experience, and support during this process. I would also like acknowledge and thank:

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- Principal Veterinary Officer Dr Yonatan (Yoni) Segal from the Chief Veterinary Officer's Unit, Department of Economic Development, Jobs, Transport and Resources (DEDJTR)
- Elliot Hill of the DHHS Food Safety Unit (FSU)
- Grant Rawlin and the Veterinary Diagnostic Services team at AgriBio
- The medical practitioners and diagnostic laboratories who notified cases to the DHHS
- The outbreak cases and their dining partners who so kindly gave their time to answer our questions throughout the investigation

Abstract

Background: On Thursday the 8th of December 2016 the CDPC unit at the Victorian DHHS was notified of multiple complaints of illness made to a Melbourne metropolitan council. Eighteen people across four different dining groups had become ill after eating an eggs benedict meal with seafood at Café X between the 4th and 7th of December 2016. An outbreak investigation was commenced to characterise and determine the extent of the outbreak, and to identify the source of infection and the pathogen causing illness.

Methods: Descriptive epidemiology was performed for all persons interviewed who ate at Café X between the 3rd and 8th of December 2016. To provide analytic evidence to support the hypothesised source of infection, a cohort study was conducted with one large group of 19 people who ate at the café on the 7th of December. Univariable analysis to calculate crude risk ratios (RR), confidence intervals (CI), and *P* values using the Fischer exact test (to account for small cell numbers) was conducted for each menu item consumed by the cohort in Stata IC 12.1 (StataCorp, Texas, United States of America). All results of the univariable analysis were infinite due to zero-cells, so an exact logistic regression was conducted for each food item with a *P* value <0.05 to determine the direction of association. Faecal samples from initial cases and food and environmental samples from Café X were collected and sent to the Microbiological Diagnostic Unit Public health Laboratory for testing. An investigation of the supplying egg farm was also undertaken.

Results: Forty-nine cases and 20 well café attendees were interviewed. Only those who reported eating some or all of the eggs benedict meal with seafood became unwell. Those who ate anything but the eggs benedict meal with seafood remained well, strongly implicating the meal as the source of infection. This was supported by the cohort study, which found only two food items to be significantly associated with illness; the eggs benedict (p-value=0.0003), and the eggs on toast (p-value=0.03). Exact logistic regression revealed that the eggs benedict was the only food item positively associated with illness, while the eggs on toast were negatively associated with illness (protective). *Salmonella* was not detected in any food or environmental samples from the café, but the investigation identified a number of food handling issues that may have contributed to contamination of the hollandaise sauce. The sauce was determined to be the most

likely source of infection in the dish. Drag swab samples from the supplying egg farm did not detect *Salmonella*, but a number of sanitation and hygiene issues were identified.

Conclusion: This investigation identified the eggs benedict meal with seafood as the source of infection, and resulted in: the removal of the affected food item from the menu; the café replacing whole egg with pasteurised egg products in high-risk foods; and improved food handling and cleaning processes at the café. These actions effectively ended the outbreak and reduced the risk of future illness being caused by this café. This investigation highlighted both the importance of comprehensive and continued training for food handlers, and the need for primary producers to implement every practicable biosecurity measure, to reduce the risk of *Salmonella* to public health.

Introduction

Caused by infection with non-typhoidal *Salmonella* bacteria, salmonellosis is a gastrointestinal disease that typically presents as a rapid development of gastrointestinal symptoms including abdominal pain, diarrhoea, muscle pain, lethargy, fever, nausea and/or vomiting.[1-2] Symptoms typically last for two to seven days and usually do not require treatment, although antibiotics may be used to reduce the severity and duration of symptoms in severe cases.[1] Children, the elderly, and immunocompromised people are most vulnerable to infection and are at higher risk of invasive infections.[1]

Transmission of salmonellosis in humans is predominantly through the consumption of food and/or beverages (and particularly those of animal origin) contaminated with the faeces of an infected person or animal. Other less common routes of transmission include person-to-person spread, contact with infected animals, and environmental exposure.[1-2] The incubation period can range between six and 72 hours, but is most commonly between 12 and 36 hours.[1]

Salmonellosis is the second most notified gastrointestinal disease in Australia, accounting for 41% of gastrointestinal disease notifications in 2014.[2] With a rate of 69.7 cases per 100,000 population, notifications in 2014 represented a 42% increase on the five year mean.[2] This trend was also observed in Victoria, which in 2016 had a notification rate of 67.4 cases per 100,000 population (4,089 cases), an increase of 33% on the five year mean.[3] It is important to recognize that although high, these numbers likely represent less than one fifth of the illness actually experienced in the community.[4] It has been estimated that approximately 85% of *Salmonella* infections are not notified to surveillance systems in Australia, as not all infected persons present to a medical practitioner and/or submit a faecal sample for laboratory testing.[4] A confirmed notification of *Salmonella* requires a positive laboratory result.[4]

Typing of *Salmonella* isolates by public health laboratories is extremely important in enabling rapid detection of outbreaks and clusters, and a number of typing methods are employed depending on the strain of *Salmonella*. In Victoria, all *Salmonella* isolates from diagnostic laboratories are sent to the Microbiological Diagnostic Unit Public Health Laboratory (MDU-PHL, often shortened to MDU) for typing (Oral communication,

OzFoodNet Victoria Epidemiologist, February 2017). All *Salmonella* isolates are first serotyped, a process which categorises the isolate into one of the 2500+ identified *Salmonella* serotypes (or serovars) using a serological test that detects O antigens in the "body" (somatic region) and H antigens in the "tails" (flagella) of the bacterium.[1,5] The serotype is then derived from the particular combination of O and H antigens present in an isolate.[5] Excepting a few particular serotypes (including *Salmonella* Typhimurium), further typing is not routinely conducted. However, in situations where further differentiation of isolates of the same serotype is required (such as in outbreak investigations) whole genome sequencing can be employed (Oral communication, OzFoodNet Victoria Epidemiologist, February 2017).

If the isolate is serotyped as *Salmonella* Typhimurium (*S.* Typhimurium), the isolate then undergoes multi-locus variable-number tandem-repeat analysis (MLVA) (Oral communication, OzFoodNet Victoria Epidemiologist, February 2017). A molecular test, MLVA examines the naturally occurring variation in the number of tandem sequence repeats in pre-defined regions (loci) of DNA.[6-7] The number of loci examined depends on the organism; for *Salmonella* five loci are examined, and results are presented as sequence five numbers separated by a hyphen (e.g. 03-09-11-14-523).[7]

MLVA only routinely replaced phage typing (examination of the different patterns of lysis resulting from the introduction of bacteriophages to an isolate[5]) as the standard test for further differentiation of *S.* Typhimurium and *S.* Subspecies I in Victoria in 2016 (Oral communication, OzFoodNet Victoria Epidemiologist, February 2017). MLVA has significantly greater discriminatory power than phage typing, which eliminates the issues encountered when trying to detect outbreaks of a particular phage type in a geographical area where that phage type predominates.[8] MLVA also eliminates the potential for inter-laboratory variance inherent in the subjective interpretation of phage typing.[9] MLVA tests and analyses are standard across laboratories in Australia, making this method more comparable and informative.[9]

In Australia the predominant *Salmonella* serotype is *S.* Typhimurium, which accounted for 47% of typed human isolates nationally in 2015.[10] In Victoria, *S.* Typhimurium had consistently accounted for between 53% and 62% of all *Salmonella* notifications in the ten years between 2006 and 2015, and only fell just below 50% in 2016.[3] *S.* Typhimurium is also, both nationally and in Victoria, the dominant causative organism of foodborne

outbreaks.[3,11-16] In the 5 year period between 2007 and 2011, *S.* Typhimurium accounted for 26-37% of foodborne outbreaks nationally, while other *Salmonella* serotypes accounted for only 3-8%.[11-15] In Victoria, *S.* Typhimurium accounted for 30-67% of foodborne outbreaks in the 5 year period between 2012 and 2016, while other serotypes accounted for 2-7%.[3, 17-20]

Of these *S.* Typhimurium outbreaks, a large proportion are associated with the consumption of eggs. Of the outbreaks known or suspected to have been associated with the consumption of eggs or egg-based dishes in Australia in the 2007-2011 period, 83-100% in each year were caused by *S.* Typhimuirum.[11-15] Similarly in Victoria, between 2012 and 2016 80-100% of egg-associated outbreaks were associated with *S.* Typhimurium.[3,17-20] Egg-based outbreaks alone represent a significant proportion of all confirmed and suspected foodborne outbreaks in Australia, accounting for 64% of outbreaks and 78% of all outbreak-associated cases nationally in the eleven year period between 2001-2011.[16] The majority of these egg-based outbreaks occurred in restaurants or other commercial food settings.[16] *S.* Typhimurium infection, especially when associated with egg-based outbreaks in restaurants and other commercial food settings that affect large numbers of people, continues to present a significant public health and food safety challenge in Victoria and across Australia.[16]

Identification of outbreak

On the 8th of December 2016, Communicable Disease Prevention and Control (CDPC) at the Victorian Department of Health and Human Services (DHHS) was notified by the Divisional Public Health Officer (DPHO) of complaints of illness received by a Melbourne metropolitan council from 4 groups of people who had eaten at a particular café in this area on the 4th, 5th, and 7th of December 2016. Complaints specified that all of those who were sick had consumed an eggs benedict with seafood dish, and that those who had not eaten this dish in these groups were not sick. One staff member of the café had also reported recent gastrointestinal illness. An outbreak investigation was initiated to determine the extent of the outbreak; to characterise the outbreak by person, place, pathogen, and time; to determine the most likely source of the reported illness; and to implement targeted public health interventions to eliminate the risk to public health and prevent further illness.

Methods

Epidemiological investigation

The café's policy was to not take bookings except for large groups, so booking lists could not be used to contact customers except for one booking of 19 people. The contact details of those who had complained to the local council were forward to CDPC for interviews to be conducted. Contact details for customers who had complained directly to the café were forwarded to the council by the café manager, and were then forwarded to CDPC. When interviewing those who had complained, contact details were sought for any other persons they had dined with.

MLVA-based case finding – the identification of further potential cases based on the MLVA pattern known to be associated with the outbreak – was undertaken through the DHHS surveillance system once the *Salmonella* serotype and MLVA pattern associated with the outbreak were established. Contact details and consent to call cases found through MLVA-based case finding were either provided on the case notification form, or were sought from the case's medical practitioner. Cases found through MLVA-based case finding were not asked for the contact details of those they had dined with as MLVA results were returned later in December, and there was limited capacity in the CDPC team to interview contacts over the Christmas and New Year holiday period. Details of whether dining companions were ill and what they had eaten, however, were collected.

Initially, the standard DHHS Gastroenteritis Outbreak case questionnaire was used to interview all reported café attendees (including those not sick). These questionnaires collected demographic details; details of medical care and specimen collection; details of symptoms experienced; details of any sick contacts in the two weeks before and after the person's visit to the café; and a free text section detailing what was eaten at the café (Appendix 1). However, it was recognised that there was a need for a menu-based questionnaire for the purposes of an analytic study. Although the menu for the café was easily accessible on their website, there was a delay in developing the questionnaire as it needed to be determined whether there had been any specials offered on the days cases had attended the café, and access to the Public Health Event Surveillance System (PHESS) database through which questionnaires are built was disrupted by a network issue.

The menu-based questionnaire, which also collected demographic, symptom, medical treatment, and contact details, was generated early in the week after notification of the outbreak to CDPC, and all but one of those interviewed with the initial questionnaire were re-interviewed. Data from completed menu-based questionnaires were entered into the PHESS database and a case list recording dining groups was maintained in Microsoft Excel. The menu-based questionnaire has not been included in the appendices to this chapter due to the identifying nature of the menu item names.

Attempts were made to interview all staff who worked at the café on the days between the 4th and 8th of December using a standard DHHS Gastroenteritis Outbreak Staff Questionnaire modified to suit the details of this particular outbreak. The staff questionnaire collected details on what duties a staff member carried out at the café; what food they handled and/or prepared; whether they ate or took home any food from the café during the period of interest; and whether they or anyone else they knew of or worked with (including other staff) had experienced any gastrointestinal symptoms.

Case definitions

Initially, a case was defined as someone who had eaten at the café between the 4th and the 8th of December 2016 who had experienced symptoms of gastrointestinal illness including diarrhoea, vomiting, nausea, abdominal pain, or fever within four days of eating at the café. Once laboratory tests had determined the causative agent of illness was *Salmonella*, the above became the probable case definition. A confirmed case was then defined as a person who ate at the café between the 4th and 8th of December 2016 who had a laboratory result positive for *Salmonella*. The date range for both definitions was later extended to begin on the 3rd of December when new cases who ate at Café X on that day were discovered. The confirmed case definition was further refined as serotyping and MLVA results became available.

Data analysis

In the process of conducting interviews it became apparent that only those who had consumed all or part of the eggs benedict dish at the café had become unwell, so the vehicle of infection was quickly identified. Given this, and considering that only café attendees who had complained and cases found through MLVA-based case finding could be interviewed, it was decided that an analytic study involving all people interviewed

would not be appropriate due to considerable selection bias, and it was not required to identify the source of infection. However, to provide analytic evidence to support the hypothesis that the eggs benedict dish was the source of infection, it was decided that a retrospective cohort study would be conducted using the interview responses from the single booking of 19 people who had all been interviewed, representing a discrete, if small, cohort. Descriptive statistics for all those interviewed would then be used to characterise the known extent of the outbreak. Staff were not included in this analysis as only two could be interviewed, including the staff member who reported illness, which was determined unlikely to be related to the outbreak.

Questionnaire data and demographic details of those interviewed were extracted from PHESS into Microsoft excel for descriptive analysis. Univariable analysis was conducted to calculate crude risk ratios (RR), confidence intervals (CI), and *P* values using the Fischer exact test (to account for small cell numbers) for each menu item consumed by the cohort. As all of the two-by-two tables involved in this analysis contained at least one zero-value cell, only a *P* value could be calculated. As such, where a result was found to be significant (*P* value <0.05), exact logistic regression was used to determine the direction of association.

This investigation was conducted as a Public Health Investigation under section 188 of the *Victorian Public Health and Wellbeing Act 2008*, and so did not require approval from a human research ethics committee.

Environmental investigation

Although the CDPC unit is notified of outbreaks wherever they occur in Victoria and coordinates most outbreak investigations, the local council that registers the food business is responsible for all environmental investigations. Shortly after the outbreak was notified to the CDPC unit on the 8th of December, the local council was requested by the DPHO to immediately undertake the following actions in accordance with the sections of the DHHS Guidelines for the Investigation of Gastroenteritis[21] relevant to a "suspected foodborne" outbreak:

- Supervise a clean-up of all food-preparation areas, common areas, and toilets, and ensure the disposal of all left-over and potentially contaminated foods that

do not undergo a kill-step, in line with the Guidelines for the Investigation of Gastroenteritis

- Obtain and submit to MDU any relevant high risk food samples
- Review hygiene, cleaning, and food handling processes at the premises, and ensure they are satisfactory
- Review the premises' Food Safety Program and conduct a Food Safety Assessment
- Ascertain whether there have been any staff unwell with symptoms of gastroenteritis and if so, inform them of relevant exclusions and hygiene procedures; collect a faecal specimen; and interview them using the gastroenteritis outbreak questionnaire
- Obtain a menu for all foods served in the period of interest, including specials
- Obtain a booking list from the premises with the names and contact phone numbers for patrons who dined in the period of interest
- Ascertain whether there have been any complaints made directly to the premises and obtain the complainant's details
- Complete the gastro outbreak onsite assessment (GOOA) and submit to CDCP unit

In addition to the above list, the local council environmental health officer (EHO) was asked to determine the processes for how the hollandaise sauce was made, and to ask for a list of suppliers of hollandaise sauce ingredients to the café. On the 12th of December the Senior Public Health Officer at the CDPC unit co-leading the investigation requested that an EHO from another local council visit the premises where a seafood ingredient of the hollandaise sauce was made to inspect the premises and determine how the ingredient was prepared.

During the environmental investigation the egg supplier for the café was identified. On the 6th of January 2017 the Chief Veterinary Officer's (CVO) unit of the Department of Economic Development, Jobs, Transport and Resources was requested to conduct an on-farm assessment of biosecurity, sanitation, hygiene, and quality assurance practices on the egg farm, and to conduct environmental sampling for *Salmonella*.

Laboratory investigation

Where specimens had not already been submitted for testing, faecal samples were requested from cases who were interviewed within the first few days of the investigation, with the delivery and pick-up of specimen collection kits organised by the CDPC unit. Samples organised by the CDPC unit were sent to directly to the Food, Environment and Outbreak Response (FEOR) section at MDU for testing, while positive samples submitted to primary diagnostic laboratories were later received at MDU for routine typing.

As part of the environmental investigation, a site visit to Café X was conducted on the 8th of December and samples of the seafood hollandaise ingredient, a new batch of the hollandaise sauce (prepared on request during the inspection), and whole eggs from the same batch as those made to use the sauce were taken for analysis. A siphon (including the nozzle) used to hold and serve the hollandaise was taken for testing on the Friday 9th of December, and it was noted that this siphon was last cleaned on Wednesday the 7th of December. The food samples and the siphon from the café were sent to the FEOR section at MDU for testing. Samples from the egg farm were sent to the AgriBio laboratory at La Trobe University.

Results

Epidemiological investigation

Descriptive analysis

In total, 34 confirmed and 15 probable cases, and 20 well café attendees who ate with these cases between the 3rd and 8th of December 2016 inclusive, were interviewed. The majority of both cases (61%) and well attendees (75%) were interviewed within seven days of eating at the café, with a median time of five days for cases (range 2-27) and six days for well attendees (range 4-61). Cases were aged between nine months and 71 years with a median age of 30 years (age missing for 3 cases), while well attendees were aged between 26 and 56 years with a median of 35.5 years. In both groups the majority were aged between 20-39 years (Figure 1). Cases were 63% female, while the number of male and female well attendees was equal.

Figure 1: Cases and well attendees at Café X by age group, December 2016

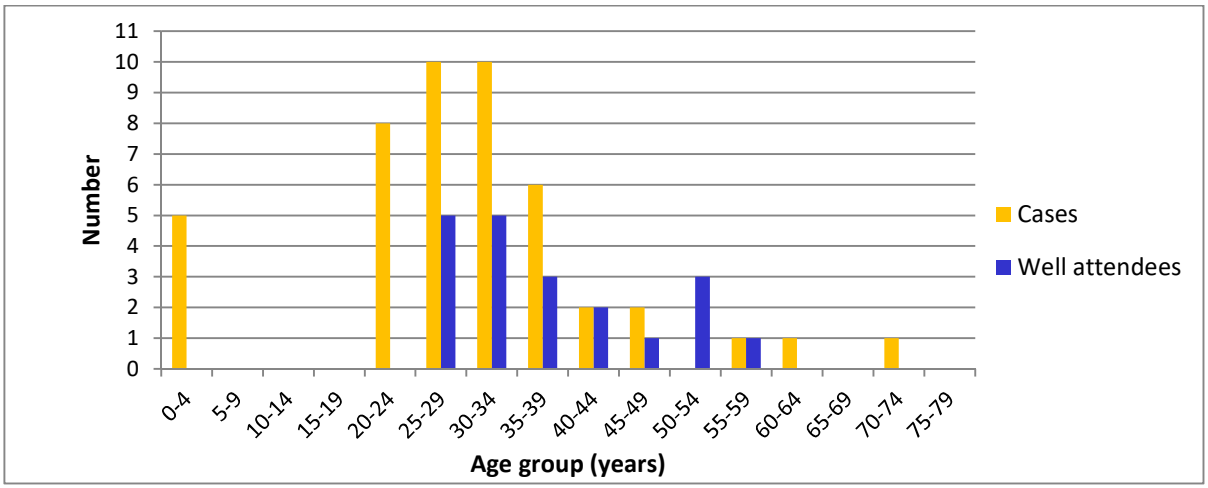


Table 1: Symptoms experienced by cases, Café X, December 2016

Symptom	%	n*
Diarrhoea	100%	49/49
Lethargy	96%	45/47
Abdominal pain	94%	45/48
Fever	93%	40/43
Headache	90%	38/42
Nausea	79%	37/47
Vomiting	52%	25/48
Blood in stools	2%	1/45
Other symptoms	35%	14/40

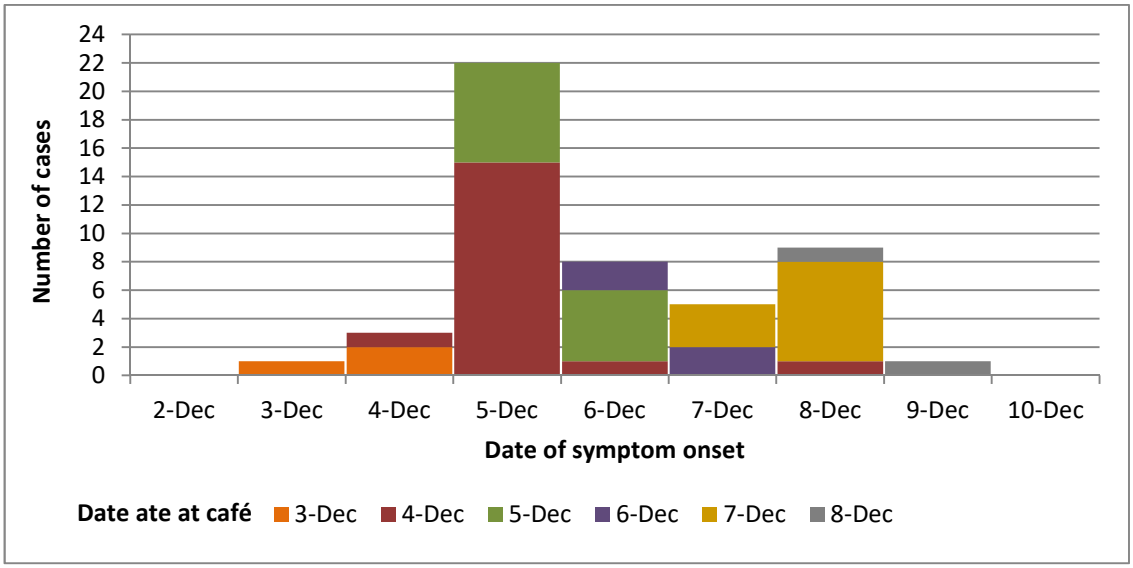
*different denominators due to missing data

All cases experienced diarrhoea, with one case reporting bloody diarrhoea. Most cases also reported fever, abdominal pain, headache and lethargy. Other symptoms are presented in Table 1 above. The majority of cases (65%) reported that their symptoms began the day after eating at the café, but a large proportion of the remaining cases (31%) reported their symptoms began later on the same day that they ate at the café. Those who ate at the café on the 5th of December had the highest proportion of same-day symptom onset, with 58% (7/12) reporting that their symptoms began later on the same day they ate at the café.

This is demonstrated in the epidemic curve presented in Figure 2. Cases are coloured according to the day on which they ate at the café to more accurately represent the time between eating at Café X and symptom onset. As can be seen in Figure 2, the peak of illness onset was on the 5th of December 2016. This peak is comprised of a large proportion of cases who ate on the 4th of December and became unwell the next day,

coupled with 58% of cases who ate on the 5th and became unwell on the same day. For the 53% of cases for whom an incubation period could be calculated (n=26), the median incubation period was 19.5 hours with a range of 2.5 to 94 hours.

Figure 2: Epidemic curve showing time to onset of symptoms by day cases ate at Café X, December 2016



At the time of interview, the reported duration of symptoms ranged between one and 14 days with a median of 7.5 days. It should be noted that six cases reported their symptoms were still continuing at time of interview. Thirty-seven cases (76%) saw a doctor regarding their symptoms, and 11 cases (22%) visited a hospital.

Of the 69 people interviewed who ate at Café X between the 3rd and 8th of December 2016, only those who reported eating some or all of the eggs benedict meal with seafood became unwell. Those who ate anything *but* the eggs benedict meal with seafood remained well.

Cohort analysis

To provide analytic evidence of this finding, a retrospective cohort study was conducted with one large group of people who ate at the café on the 7th of December. Their ages ranged between 26 and 56 years (median of 37 years) and 63% (12) were male. Four of the group, who had all consumed the eggs benedict meal with seafood, became unwell after eating at the café. The incubation periods for these cases were 11.5, 13.5, 24, and 38.5 hours. All cases experienced watery diarrhoea, abdominal cramps, fever, and lethargy. Three cases experienced nausea and headache, and two vomited. All cases had experienced at least seven days of symptoms, and three cases were still experiencing

symptoms at the time of interview. All cases saw a doctor for their symptoms, and one case was admitted to hospital. Only one case submitted a faecal sample, which was positive for *S.* Typhimurium MLVA pattern 03-09-09-15-523 (the outbreak strain).

The overall attack rate in the cohort was 21%, though the food-specific attack rate for the eggs benedict meal with seafood was 100%. The univariable analysis found two food items to be significantly associated with illness; the eggs benedict (*P* value=0.0003), and the eggs on toast (*P* value=0.03) (Table 2). Exact logistic regression revealed that the eggs benedict was the only food item positively associated with illness, while the eggs on toast were negatively associated with illness (protective).

Table 2: Univariate cohort analysis of foods consumed by ill (n=4) and not ill (n=15) café attendees with statistically significant results highlighted in red

Menu item	Ill		Not ill		Risk ratio	Confidence Interval	*P* value
	n	%	n	%			
Eggs benedict meal with seafood	**4**	**100**	**0**	**0**	**-**	**-**	**0.000**
Plain toast	0	0	1	6.67	-	-	1.000
Eggs on toast	**0**	**0**	**10**	**66.67**	**-**	**-**	**0.033**
Meat breakfast meal	0	0	1	6.67	-	-	1.000
Vegetarian breakfast meal	0	0	1	6.67	-	-	1.000
Smoked salmon and ricotta croissant	0	0	1	6.67	-	-	1.000
Smoked salmon scrambled eggs	0	0	1	6.67	-	-	1.000
Any side	0	0	6	40	-	-	0.255
Hot drink	4	100	13	86.67	-	-	1.000
Cold drink	0	0	6	40	-	-	0.255

Environmental investigation

Two visits were made to the café on the 8th and 9th of December 2016. On the 8th of December the local council ordered a clean-up of the café and took samples of the seafood hollandaise sauce ingredient, hollandaise sauce, and whole eggs. As all hollandaise made in the period of interest had been used, a fresh batch was made and sampled at the time of the visit. There were no left-over foods which required disposal. A list of staff who worked in the period of interest was provided, including the details of the sick staff member.

The café reported that they had stopped serving the eggs benedict meal with seafood on the morning of the 8th of December after the manager had received complaints implicating the meal, although as described above, this dish was still being served at

breakfast time on that day. As an indication of the potential scope of the outbreak, the café estimated that they served approximately 400 diners per day, and had recorded selling 132 serves of the eggs benedict meal with seafood between Saturday the 3rd and Monday the 5th of December.

The EHOs who attended the restaurant found no major deficiencies in the maintenance and condition of the premises, and the food safety records of the premises were reported to be complete and accurate. The local council EHO obtained the ingredient list for the hollandaise sauce, the process for making the sauce, and the process for cleaning the hollandaise siphons. On review of the processes provided to the EHO, the CDPC PHO noticed that the café stated that after the hollandaise was made, it was stored in the refrigerator for service. The PHO recognised that this information was inaccurate, as a hollandaise sauce will solidify if kept in the fridge. Further investigation by the EHO clarified the process, and a revised procedure was provided stating that after preparation the hollandaise sauce was kept in a warm water bath for use during service as required. It was not stated for how long the siphons were kept in the warm water bath.

This revised process also stated that eggs for the hollandaise were separated with egg shells or by hand, whereas the first process description had stated that eggs were separated using a spoon after being cracked into a bowl. Further, the investigation of the processes for cleaning the hollandaise storage/serving siphons also revealed that the dishwasher rinse cycle temperature was not set high enough to effectively sanitise the equipment (55°C). As a result of these investigations, the café was directed under the *Food Act 1984* to cease the practice of separating eggs using the shells and to set the dishwasher rinse cycle to a minimum temperature of 77°C for a minimum of 30 seconds for effective sanitisation.[22] After consultation between the café and the local council it was decided that to minimise risk of future foodborne outbreaks the café would replace raw egg products with pasteurised egg products, and that the eggs benedict meal with seafood would be permanently removed from the menu.

The eggs benedict meal with seafood meal consisted of toast, two poached eggs, cooked tiger prawns, a seafood bisque hollandaise sauce, and a fried noodle garnish. On the 14th of December 2016 an EHO from another local council visited the premises where the seafood bisque was prepared. The processes for making, storing, and delivering the

bisque were reviewed and found to be satisfactory, as were the food safety records kept by the business.

On the 12th of January 2017 a veterinary officer from DEDJTR conducted an inspection at the egg farm that supplied the café. The farm was found to house approximately 25,000 laying hens under both free range and caged conditions. A number of operational issues were discovered that resulted in an assessment that farm biosecurity was low: the farm was found to not have any rodent or insect control programmes; wild birds and chicken body parts were observed inside chicken sheds (possibly due to fox activity); and there were no foot baths or change of clothing and footwear procedures in place. However, there was a process in place to separate all soiled eggs and those found on the floor from other eggs and to send these for pasteurisation. A new egg washing machine had also been recently purchased.

Laboratory investigation

Six cases provided faecal samples that were sent directly to the Food, Environment and Outbreak Response (FEOR) section at MDU for testing. A further 28 cases either submitted faecal samples on the advice of their general practitioner (GP) or had samples taken when they visited a hospital. One case submitted a faecal sample organised by the CDPC unit, and had a second sample taken when admitted to hospital. In total, 34 cases submitted faecal samples.

Of the 34 human samples submitted, two had *Salmonella* detected only by PCR, and 32 were typed by MDU as *S.* Typhimurium. Of the 32 *S.* Typhimurium, 25 had the MLVA pattern 03-09-09-15-523 and seven had the pattern 03-09-09-14-523. The definition employed by the DHHS in interpreting MLVA patterns and the level of variation between them is that if two patterns differ by only one digit at only one of the three middle loci at once (not the first or last loci), the two patterns most likely represent the same organism (Oral communication, OzFoodNet Victoria Epidemiologist, February 2017). As such, all cases with MLVA typing were deemed to have been infected from the same common source.

Salmonella was not isolated from any of the environmental or food samples taken from the café, nor from the drag swabs taken from two free range and two caged hen sheds at the egg farm.

Discussion

This investigation describes an outbreak of Salmonellosis caused by *S.* Typhimurium 03-09-09-15-523/03-09-09-14-523 among people who ate at Café X between the 3rd and 8th of December 2016 inclusive. The epidemic curve suggests a continuous common-source outbreak over six days, with no additional cases arising after control measures were implemented at the café. Investigation of this outbreak and the speed with which control measures could be taken was aided by the early identification of the source of illness– the eggs benedict meal with seafood. This meal consisted of toast, two poached eggs, cooked tiger prawns, a hollandaise sauce containing seafood bisque, and a fried noodle garnish. We are confident that the source of the outbreak was restricted to this meal as all persons who were ill reported eating some or all of this dish. Those who reported eating anything other than this meal at Café X in the period of interest remained well, and the cohort study analysis found this to be the only dish statistically associated with illness. In addition, the café stopped serving this dish late in the morning of the 8th of December, and we did not identify any cases who ate at Café X after this time.

Although *Salmonella* was not isolated from samples of the seafood bisque, the fresh batch of hollandaise sauce, or one of the hollandaise storage/serving siphons, it was determined that the hollandaise sauce served in the period of interest was the most likely vehicle of infection for a number of reasons:

- As discussed previously, *S.* Typhimurium is commonly associated with egg-based outbreaks, and this particular MLVA pattern was associated with another large egg-based outbreak in Victoria in 2015.[17] The phage type commonly associated with this MLVA pattern (phage type 170) was also associated with 10 egg-based outbreaks in Victoria in the five years between 2010 and 2014;[18-20,23-24]
- Given that 80% (16/20) of well-attendees ate another dish containing made-to-order poached, fried, or scrambled eggs at the café at the same time as cases and did not become unwell, it is unlikely that the poached eggs served with the implicated meal caused the illness;
- It may have been possible that the prawns were the contaminated food item, but this is unlikely due to the fact that prawns are not commonly associated with

Salmonella outbreaks in Australia, and are also not commonly associated with *S.* Typhimurium.[11-15] The prawns in the dish were also fully cooked and made to order, and a number of cases reported only consuming the hollandaise sauce from the dish. If the prawns were the contaminated item, cross-contamination of the sauce would be possible, but it is unlikely that in the short-period between service and consumption that there would be enough contamination of the sauce to cause the severity of observed illness in cases who only consumed the sauce;

- It is also unlikely that the seafood bisque added to the hollandaise sauce was the source of infection as *Salmonella* was not isolated from a sample of the same batch of bisque used in the hollandaise in the period of interest;
- The toast is biologically implausible as a food vehicle for *Salmonella* given the product is fully cooked at high temperatures, and was sourced from a large commercial bakery. If the bread was the source of infection it would likely have affected more establishments/customers. Additionally, one case reported substituting the toast for another type of bread, which supports the evidence that the toast was not the source of infection;
- Hollandaise sauce is widely acknowledged to be a 'high risk food'.[22] For the sauce to maintain the appropriate texture the eggs cannot be cooked to a temperature that would kill *Salmonella*. Further, in a busy restaurant setting such as Café X, batches of sauce are made in advance of service and kept warm to retain the consistency of the sauce. If not strictly temperature controlled, this process can keep the sauce at a temperature that promotes *Salmonella* growth,[25] as *Salmonella* grows in temperatures between 5.2 and 46.2°C with an optimal temperature of 35-43°C.[26] The café reported making two batches of hollandaise per day which were decanted into serving siphons and kept in a warm water bath for service. They reported discarding any remaining sauce after the breakfast/lunch service period, but as there were no records of batches made on the days in question, it is unclear whether sauce is always strictly discarded after four hours as per the two hour/four hour guidelines,[22] which could encourage *Salmonella* growth in the sauce;

- The café was relying on the dishwasher temperature to sanitise the siphons used to store and dispense the hollandaise sauce. The environmental investigation revealed that the dishwasher rinse cycle temperature and time was not adequate to achieve effective sanitising of this equipment. This may have resulted in cross-contamination from an initial contaminated batch of hollandaise sauce to subsequent batches made over the six day period of the outbreak;
- And finally, the high-risk preparation process of separating the eggs for the hollandaise sauce using eggshells or hands identified during the environmental investigation points to a likely point of contamination of the sauce.

It remains unclear whether all or some of the batches of hollandaise sauce made in the period of interest were contaminated, as we were unable to interview everyone who ate the implicated hollandaise sauce over this period. It is also unclear exactly how the hollandaise sauce became contaminated. Given that the café reported making fresh batches of sauce twice a day, and that contamination in batches of eggs is usually low,[27] it is unlikely that one or more eggs in each batch were contaminated with *Salmonella*. It is more plausible that given the outbreak was sustained over a period of so many days, one or more of the siphons was contaminated and continued to contaminate fresh batches of sauce as they were filled. This hypothesis is supported by the discovery of insufficient cleaning and sanitising processes for the siphons during the environmental investigation. Although the siphon parts were reported to be soaked in 'heavy duty' detergent, studies have shown that washing dishes with detergent at standard hot water temperatures (45-50° Celsius) is not sufficient to kill *Salmonella,* even when a rinse step is included.[28-30] As no chemical sanitisers were used, the premises was relying on an insufficient dishwasher temperature to provide the sanitising step.

This outbreak highlights issues around the production and serving of high risk foods in restaurant/café settings. Sauces and condiments that contain raw or undercooked eggs (e.g. hollandaise sauce, mayonnaise, and aioli) are often produced and stored until they are served. This can result in large and prolonged outbreaks, especially if there are improper food handling, food storage, and/or unsatisfactory cleaning and sanitation processes at the establishment. With demand for these types of egg-based high risk foods growing, it is integral that food handlers are adequately trained and employ

proper food handling and hygiene practices.[31] In this outbreak it appeared that the café was aware of proper food handling processes as they reported food production processes in line with these (e.g. reporting the refrigeration of a semi-cooked egg product, and the separation of eggs with a spoon) to the investigating EHO. However, in practice, these procedures were not adhered to. This reinforces the need for food handlers to understand exactly how and why contamination of foods can occur and the circumstances which allow for the growth of bacteria in foods, and for regular reviews of adherence to appropriate food handling procedures to take place.

The use of pasteurised egg products in raw and undercooked foods should also be considered by food premises.[32] Café X has taken positive action following this outbreak by using pasteurised egg product in any uncooked or semi-cooked food items, and it is hoped that this action will be continued. A contemporary example, however, demonstrates how consumer demand can override safe food practices. Through the active case finding for this outbreak, another outbreak with the same MLVA pattern was identified and was found to be associated with consumption of Vietnamese pork rolls from a particular bakery. This bakery had a *Salmonella* outbreak the previous year, also associated with Vietnamese pork rolls. As a result of the first outbreak the bakery had agreed to use pasteurised egg products in its mayonnaise, but had apparently returned to using raw egg after regular customers complained about the change in product flavour. Balancing consumer demand with food safety requires food businesses and food handlers to be thoroughly educated in the risks of raw and semi-cooked food products and the processes required to reduce the risk of contamination and bacterial growth.

Ideally, consumers should also be aware of high-risk foods before they choose to consume them. Anecdotally, many cases interviewed during the course of this investigation had limited knowledge of why a hollandaise sauce might be classified as 'high risk' and the pathways through which it might become contaminated. One way to increase consumer awareness might be to implement consumer advisory notices for raw or semi-cooked foods on menus, as recommended by the USA Food and Drug Administration (FDS) Food Code.[33]

This outbreak investigation exemplifies the responsibility of egg producers to ensure all measures are taken to provide uncontaminated product to customers. DEDJTR reported

that the farm assessed as part of this investigation had a number of operational issues that could potentially contribute to the likelihood of *Salmonella* infection of their laying hens, and the subsequent contamination of their eggs. Given the complex and often difficult-to-control range of factors that can contribute to the potential for contamination at the production level,[34] it is vital that both egg producers and food businesses recognize and address the potential for contamination by implementing control measures to reduce the risk of *Salmonella* contamination of eggs and egg products.

Limitations

Given that Café X advised that it sold 132 serves of the eggs benedict meal with seafood over 3 days (with the outbreak taking place over 6 days), and that the majority of people with *Salmonella* don't get diagnosed and notified to a surveillance system,[4] it is likely that the number of cases identified in this outbreak investigation greatly underrepresents the number of people affected. However, this assumes that all servings of the eggs benedict meal with seafood were contaminated, and that all people who consumed the contaminated food became symptomatic. If this outbreak was in fact propagated by contaminated storage and serving siphons, it is possible that not all siphons were contaminated, and that only some batches of the hollandaise sauce were contaminated. Unfortunately, as the café didn't have booking lists, it is impossible to know whether other café attendees ate the eggs benedict meal with seafood in the period of interest and did not become sick.

Because of the lack of booking lists we were also unable to conduct a larger analytic study that included all cases due to the selection bias inherent in only being able to speak with café attendees who complained or cases found through MLVA-based case finding. Luckily one group booking was able to be used to perform a cohort study, but this was still a small sample size which limited the study's statistical power to test hypotheses. However, we were still able to obtain a statistically significant finding in the cohort analysis, which contributed to the evidence implicating the eggs benedict meal with seafood.

Microbiological evidence for the suspected food source of infection (the seafood bisque hollandaise sauce) was not obtained, but this was not unexpected for a number of

reasons: the hollandaise sauce that was tested was not the same sauce that was served in the outbreak period; the siphon that was tested had been cleaned in the two days beforehand; and it is unlikely that more than a few eggs in the batch used to make the hollandaise sauce were contaminated.[27,35] Environmental swabs from the egg farm were also negative for *Salmonella*, but again this was not surprising given that excretion of *Salmonella* in infected chickens can be intermittent, and the egg farm was sampled over a month after the outbreak occurred.[36] This may be a contributing factor as to why approximately 50% of *Salmonella* outbreak egg farm trace back investigations fail to isolate the outbreak strain.[37]

Despite these limitations, this outbreak investigation succeeded in:

- Identifying the food source which caused this outbreak;
- Preventing the further spread of illness by removing the menu item from sale;
- Reducing the risk of further outbreaks from this premises by instigating the permanent removal of the eggs benedict meal with seafood from the menu; prompting the use of pasteurised egg by the premises; instituting effective cleaning processes; and amending issues in food handling procedures; and
- Identifying and providing recommendations to improve hygiene, sanitation, and quality assurance processes at the supplying egg farm

This outbreak investigation also gave us an opportunity to provide both the food establishment staff and affected customers with a greater knowledge and understanding of *Salmonella* transmission, risk factors, and illness prevention.

Conclusions

This outbreak of *Salmonella* Typhimurium MLVA 03-09-09-15-523/03-09-09-14-523 at Café X in December 2016 was found to be associated with consumption of an eggs benedict with seafood dish, of which the hollandaise sauce component was the most likely food vehicle. The investigation resulted in the removal of this food item from the menu, the replacement of raw egg with pasteurised egg products for high risk foods, and improved food handling and cleaning processes at Café X. It will hopefully also result in improved hygiene and sanitation processes at the egg farm. This outbreak highlighted the necessity of raising awareness amongst food handlers about safe preparation and

storage of high risk foods, and the importance of continued adherence to these procedures. It also highlighted the importance of employing every practicable measure at the primary production level to avoid contamination of eggs and egg products prior to sale.

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Appendices

Appendix 1: DHHS Gastroenteritis Outbreak case questionnaire

Case questionnaire

Gastroenteritis outbreak

Victoria Department of Health

Outbreak name:

NIDS No:

NIDS updated:

Has the organism been isolated? ☐ Yes ☐ No

If yes, name:

Date of interview:

Interviewer:

Person interviewed (if not the case):

Interpreter used? ☐ Yes ☐ No

PRIVACY MESSAGE: The information you provide in this questionnaire is for the purpose of trying to prevent further cases of illness. We do this by trying to find out what is likely to have caused your illness and also by providing you with information to reduce the spread of illness to others. The data collected is kept confidential and identifying information will not be disclosed for any other purpose without your consent. You can access your information by contacting the Department of Health. A fact sheet is available ("Privacy Legislation & Notification of Infectious Diseases – Information for Patients") if you would like further information. **Information read?** ☐

Case details

Surname/ family name

First name

Street address

Suburb

Postcode

Name of parent/guardian (if applicable)

Contact details

Daytime tel

Evening tel

Mobile tel

Email

Birth date

Sex ☐ Male ☐ Female

Country of birth

Year of arrival (if outside Australia)

Language spoken

ATSI status *(tick all that apply)*:
☐ Aboriginal
☐ Torres Strait Islander
☐ Not indigenous
☐ Not stated

Occupation

OR ☐ child at home ☐ child in child care ☐ pensioner ☐ student ☐ unemployed ☐ home duties

High risk group? ☐ Yes ☐ No

High risk groups are food handlers, health care workers, child care workers, children in child care, and residents of institutions (e.g. aged care).

If yes:
Workplace/child care address and contact details:

Date last attended before onset of illness

Date returned to work/child care

Appendix 2: Case questionnaire: *Gastroenteritis outbreak* Page 1 of 5

Treating doctor/hospital

Name of treating doctor

Address | Postcode

Telephone | Facsimile

Mobile tel | Email

Consent given by doctor to interview case ☐ Yes ☐ No | Date consent provided

Did the case present to hospital? ☐ Yes ☐ No | If yes, date presented to hospital

Was the case admitted to hospital? ☐ Yes ☐ No

Name of hospital | Address

Date of admission | Date of discharge/death

Hospital UR No

Illness summary

Onset date of illness | Time of onset | am/pm | Date of specimen collection

Type of specimen ☐ Faeces ☐ blood ☐ urine ☐ other

Symptoms		Onset date of symptom	History of illness
Diarrhoea	☐ Yes: ☐ watery ☐ bloody Duration of diarrhoea (days) ☐ No		
Nausea	☐ Yes ☐ No		
Vomiting	☐ Yes ☐ No		
Abdominal pain	☐ Yes ☐ No		
Lethargy	☐ Yes ☐ No		
Headache	☐ Yes ☐ No		
Other (specify)	☐ Yes ☐ No		
Total duration of illness hours days			

Treatment

Were antibiotics given to treat the illness? ☐ Yes ☐ No | If yes, what antibiotics?

Are you still taking antibiotics? ☐ Yes ☐ No | What date did you last take the antibiotics?

Comments on treatment

Appendix 2: Case questionnaire: *Gastroenteritis outbreak*

Page 2 of 5

Contacts

In the two weeks before the onset of the illness, has the case:
- had contact with a family member with a similar illness? ☐ Yes ☐ No *If yes give details in table below*
- had contact with a friend or work/school colleague with a similar illness? ☐ Yes ☐ No *If yes give details in table below*

Name	Relationship	Address and phone	Occupation/childcare/school	Onset date

In the two weeks after the onset of the illness in the case
- have any family members been ill with similar symptoms? ☐ Yes ☐ No *If yes give details in table below*
- have any friends or work/school colleagues been ill with similar symptoms? ☐ Yes ☐ No *If yes give details in table below*

Name	Relationship	Address and phone	Occupation/childcare/school	Onset date

Note: A *food and water borne* questionnaire should be completed for identified ill cases

How well did the case recall the information (doctor's details, illness history and contacts)? ☐ Very well ☐ Well ☐ Not well ☐ Not at all

Food/activity history

Attach extra notes if necessary

Signature

Name of interviewer (please print clearly)

Signature

Date

How long did this questionnaire take to complete?

Attempts to contact case

Date	Time	Comments

Investigation notes

Attach extra investigation notes if necessary.

Appendix 2: Late draft manuscript for submission to the *Communicable Diseases Intelligence* journal

The "sauce" of infection: an outbreak of *Salmonella* Typhimurium associated with hollandaise sauce served at a Melbourne café

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Abstract

Salmonella Typhimurium is the most frequently notified *Salmonella* serotype in Australia and is the causative pathogen in the majority foodborne outbreaks associated with eggs and egg-based products. In December 2016 an outbreak of *Salmonella* Typhimurium occurred in patrons of a Melbourne café who had all consumed an eggs benedict meal with a hollandaise sauce containing seafood bisque. As no booking lists were available, we conducted a retrospective cohort study analysis with one large group booking that ate the café in the outbreak period to confirm the association between illness and consuming the eggs benedict meal. The univariable analysis found two food items to be significantly associated with illness; the eggs benedict (*P* value=0.0003), and the eggs on toast (*P* value=0.03). Exact logistic regression revealed that the eggs benedict was the only food item positively associated with illness. Although *Salmonella* was not isolated from any environmental samples from the café, the investigation by the local council revealed that the café employed improper food handling processes in the creation of the hollandaise sauce, and that cleaning processes were not sufficient for the sterilisation of equipment used to store and serve the hollandaise sauce. This outbreak highlights the necessity of raising awareness amongst food handlers about safe preparation and storage of high-risk foods, and the importance of continued adherence to these procedures. Awareness of hollandaise sauce as a high-risk food for *Salmonella* infection in the general public could be improved by including warning messages on menus.

Keywords: outbreak, *Salmonella*, eggs, hollandaise, cohort study, public health

Introduction

Salmonellosis is the second most notified gastrointestinal disease in Australia, accounting for 41% of gastrointestinal disease notifications in 2014.[1] The predominant *Salmonella* serotype in Australia is *Salmonella.* Typhimurium (STm), which accounted for 47% of typed notifications nationally in 2015.[2] STm is also the dominant causative organism of foodborne outbreaks, a large proportion of which are associated with eggs.[3-8] Egg based outbreaks alone accounted for 64% of outbreaks in Australia between

2001 and 2011, and the majority of these egg-based outbreaks occurred in restaurants or other commercial food settings.[8]

On the 8th of December 2016, Communicable Disease Prevention and Control (CDPC) at the Victorian Department of Health and Human Services (DHHS) was notified of complaints of illness received by a Melbourne metropolitan council from four groups of people who had eaten at a particular café in this area between the 4th and 7th of December. Complaints specified that all of those who were sick had consumed an eggs benedict with seafood meal. An outbreak investigation was initiated to determine the source of illness and to implement appropriate public health interventions to prevent further illness.

Methods

Epidemiological investigation

Café X did not take bookings except for large groups, so apart from one booking of 19 people, booking lists couldn't be used to contact customers. Cases were identified through complaints to the café and to local council, and contact details were forwarded to the CDPC unit for interviews to be conducted. During interviews, contact details were sought for any other persons cases had dined with, and active case finding using the outbreak MLVA pattern was also conducted. Cases and well café attendees were interviewed with a menu-based questionnaire. Attempts were also made to interview all staff who worked at the café between the 4th and 8th of December.

A probable case was defined as someone who had eaten at the café between the 3rd and 8th of December 2016 who had experienced symptoms of gastrointestinal illness including diarrhoea (two or more loose bowel motions within 24 hours), vomiting, nausea, or abdominal pain within 4 days of eating at the café. A confirmed case was defined as a person who ate at the café in the same period who had a laboratory result positive for *Salmonella,* later refined to STm associated with Multiple Locus Variable-number Tandem Repeat Analysis (MLVA) profile 03-09-09-15-523 or 03-09-09-14-523.

Descriptive statistics for all people interviewed were used to characterise the outbreak. Staff were not included in this analysis as only two could be interviewed, including the

staff member who reported illness, and it was determined that this illness was likely unrelated to the outbreak.

It quickly became apparent that only those who had consumed all or part of the eggs benedict dish at the café had become unwell, making a large analytic study unnecessary. However, to provide analytic evidence of the association between consumption of the implicated meal and illness, a retrospective cohort study was conducted using interview responses from the single booking of 19 people.

Questionnaire data and demographic details of those interviewed were extracted from the DHHS Public Health Event Surveillance System (PHESS) into Microsoft Excel for descriptive analysis. For the cohort study, univariable analysis to calculate crude risk ratios (RR), confidence intervals (CI), and *P* values using the Fischer exact test was conducted in Stata IC 12.1 (StataCorp, Texas, USA) for each menu item consumed by the cohort. All results of the univariable analysis were infinite due to zero-cells, so an exact logistic regression was conducted for each food item with a *P* value <0.05 to determine the direction of association.

Environmental investigation

In line with the Victorian DHHS Guidelines for the Investigation of Gastroenteritis,[9] the local council environmental health officers (EHOs) visited the café on the 8th and 9th of December 2016 to review the hygiene, cleaning, and food handling processes at the premises; obtain a menu for all foods served between the 3rd and 8th of December; obtain samples of any relevant high-risk foods; obtain the process for how the eggs benedict was prepared and a list of ingredients and suppliers; ascertain whether any staff had been unwell with gastroenteritis symptoms; and supervise a clean-up of all food preparation areas, common areas, and toilets.

On the 12th of December a local council EHO visited the premises where the seafood bisque was made to inspect the premises and determine how the seafood bisque was prepared. The egg farm that supplied the café was also inspected by a Veterinary Officer from the Department of Economic Development, Jobs, Transport and Resources (DEDJTR) on the 6th of January 2017, and an assessment of biosecurity, sanitation, hygiene, and quality assurance practices on the egg farm and environmental sampling for *Salmonella* was conducted.

Laboratory investigation

Faecal samples and *Salmonella* isolates submitted by primary diagnostic laboratories were tested by the Microbiological Diagnostic Unit Public Health Laboratory (MDUPHL). All environmental samples and equipment from the café were tested by the Food, Environment, and Outbreak Response (FEOR) section at MDUPHL. Samples from the egg farm were sent to the AgriBio laboratory at La Trobe University.

This investigation was conducted as a Public Health Investigation under section 188 of the *Victorian Public Health and Wellbeing Act 2008*, so did not require approval from a human research ethics committee.

Results

Epidemiological investigation

In total, 69 people who ate at the café between the 3rd and 8th of December were interviewed. Forty-nine were cases (34 confirmed and 15 probable) and 20 were not ill. Cases were aged between nine months and 71 years with a median age of 30 years (age missing for three cases) and 63% were female.

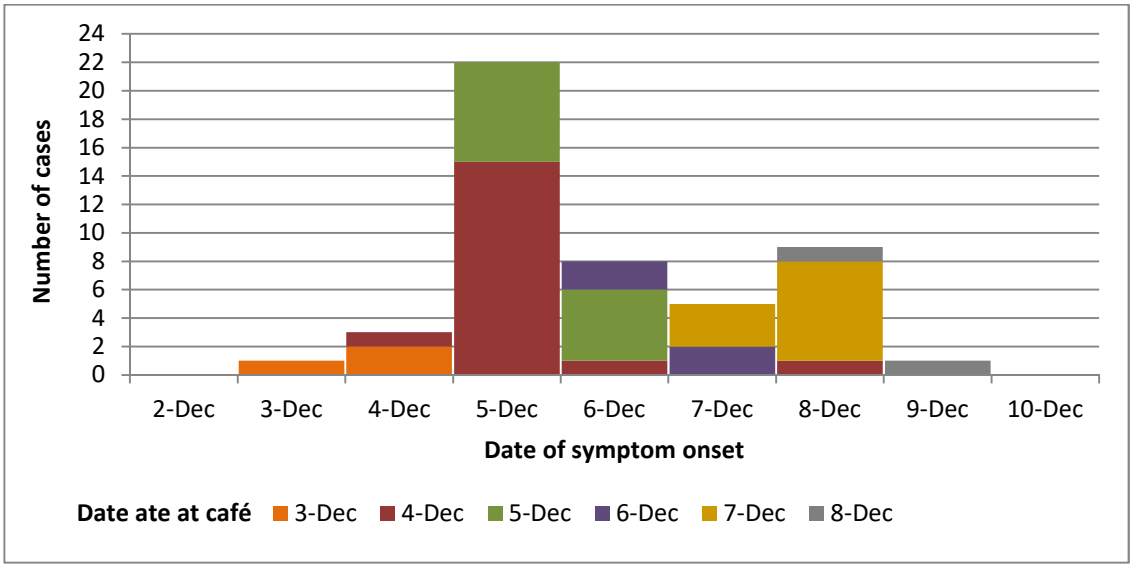
All cases experienced diarrhoea, with one case reporting bloody diarrhoea. Most cases also reported fever, abdominal pain, headache and lethargy (Table 1). The majority of cases (65%) reported that their symptoms began the day after eating at the café, but a large proportion of the remaining cases (31%) reported their symptoms began later on the same day that they ate at the café (Figure 1). For the 26 cases for whom an incubation period could be calculated, the median incubation period was 19.5 hours (range 2.5–94 hours). At the time of interview, the reported duration of symptoms ranged between one and 14 days with a median of 7.5 days. Thirty-seven cases (76%) went to see a doctor regarding their symptoms, and 11 cases (22%) visited a hospital.

Table 1: Symptoms experienced by cases, Café X, December 2016

Symptom	%	n*
Diarrhoea	100%	49/49
Lethargy	96%	45/47
Abdominal pain	94%	45/48
Fever	93%	40/43
Headache	90%	38/42
Nausea	79%	37/47
Vomiting	52%	25/48
Blood in stools	2%	1/45
Other symptoms	35%	14/40

*different denominators due to missing data

Figure 1: Epidemic curve showing time to onset of symptoms by day cases ate at Café X, December 2016



Interviews revealed that only those who ate some or all of the eggs benedict meal with seafood became unwell. To provide analytic evidence of this finding, a cohort study was conducted with the group booking of 19 people who ate at the café on the 7th of December. Their ages ranged between 26 and 56 years (median 37 years) and 12 (63%) were male. The group included four cases, all who had consumed the implicated meal.

The overall attack rate in the cohort was 21%, though the food-specific attack rate for the eggs benedict was 100%. The univariable analysis found two food items to be significantly associated with illness; the eggs benedict (*P* value=0.0003), and the eggs on toast (*P* value=0.03) (Table 2). Exact logistic regression revealed that the eggs benedict meal with seafood was the only food item positively associated with illness, while the eggs on toast were negatively associated with illness (protective).

Table 2: Univariate cohort analysis of foods consumed by ill (n=4) and not ill (n=15) café attendees with statistically significant results highlighted in red

Menu item	Ill		Not ill		Risk ratio	Confidence Interval	*P* value
	n	%	n	%			
Eggs benedict meal with seafood	**4**	**100**	**0**	**0**	**-**	**-**	**0.000**
Plain toast	0	0	1	6.67	-	-	1.000
Eggs on toast	**0**	**0**	**10**	**66.67**	**-**	**-**	**0.033**
Meat breakfast meal	0	0	1	6.67	-	-	1.000
Vegetarian breakfast meal	0	0	1	6.67	-	-	1.000
Smoked salmon and ricotta croissant	0	0	1	6.67	-	-	1.000
Smoked salmon scrambled eggs	0	0	1	6.67	-	-	1.000
Any side	0	0	6	40	-	-	0.255
Hot drink	4	100	13	86.67	-	-	1.000
Cold drink	0	0	6	40	-	-	0.255

Environmental investigation

Two visits were made to the café on the 8th and 9th of December 2016. On the 8th of December the local council ordered a clean-up of the café, requested a list of ingredients for the hollandaise sauce and their suppliers, and took samples of the seafood bisque, hollandaise sauce, whole eggs from the same batch as was used to make the hollandaise sauce in the outbreak period, and one of the siphons used to store and serve the hollandaise sauce. As all hollandaise made in the period of interest had been used, a fresh batch was made to be sampled. A list of staff who worked in the period of interest was provided, including the details of the sick staff member. The café reported that they had stopped serving the eggs benedict meal with seafood on the morning of the 8th of December after the manager had received complaints implicating the meal.

The café was found to have no major deficiencies in the maintenance and condition of the premises. The process for making the hollandaise sauce provided by the café stated that eggs were separated with a spoon and that the hollandaise sauce was kept in the refrigerator after production. Upon further discussion with kitchen staff, this process was found to be inaccurate and a second description of the process revealed that eggs were separated with shells or by hand, and that the sauce was kept in a warm water bath in siphons for use during service as required. The council was also provided with the processes for cleaning the siphons, which revealed that although the siphon heads were soaked in detergent, the dishwasher rinse cycle temperature was not set high enough to effectively sanitise the equipment (55°C).

This eggs benedict meal with seafood consisted of toast, two poached eggs, cooked tiger prawns, a hollandaise sauce containing seafood bisque, and a fried noodle garnish. On the 14th of December 2016 the council visited the premises where the seafood bisque was prepared. The processes for making, storing, and delivering the bisque were found to be satisfactory, as were the food safety records kept by the business. The farm that supplied the café with eggs was visited on the 12th of January 2017. A number of operational issues were discovered that resulted in an assessment that farm biosecurity was low.

As a result of these investigations, the café was directed under the *Food Act 1984* to cease the practice of separating eggs using the shells and to set the dishwasher rinse cycle to a minimum temperature of 77°C for a minimum of 30 seconds for effective sanitisation.[10] After consultation between the café and the local council it was decided that to minimise risk of future foodborne outbreaks the café would replace raw egg with pasteurised egg products, and that the eggs benedict meal with seafood would be permanently removed from the menu.

Laboratory investigation

Of the 34 human samples submitted for testing 2 had *Salmonella* only detected by PCR and 32 were typed as STm. Of these 32, 25 had the MLVA pattern 03-09-09-15-523 and seven had the pattern 03-09-09-14-523. Being only one digit different at only one of the three middle loci, these two patterns indicated that all cases with MLVA typing were infected from the same common source. *Salmonella* was not isolated from any of the environmental or food samples taken from the café, nor from the drag swabs taken from the egg farm.

Discussion

This investigation describes an outbreak of Salmonellosis caused by STm 03-09-09-15-523/03-09-09-14-523 among people who ate at Café X between the 3rd and 8th of December 2016 inclusive. The epidemic curve suggests a continuous common-source outbreak over six days, with no additional cases arising after control measures were implemented at the café. The investigation of this outbreak and the speed with which control measures could be taken was aided by the early identification of the source of

illness– the eggs benedict meal with seafood. We are confident that the source of the outbreak was restricted to this meal as all persons who were ill reported eating some or all of this dish; the cohort study analysis found this to be the only dish statistically associated with illness; and no new cases were identified after the café stopped serving this dish late in the morning of the 8th of December.

Although *Salmonella* was not isolated from the environmental samples of the hollandaise sauce or the storage/serving siphon, it was determined that the hollandaise sauce served in the outbreak period was the most likely vehicle of infection. The poached eggs served with the meal were unlikely to have been the vehicle of infection as 80% (16/20) of well-attendees ate another dish containing poached, fried, or scrambled eggs at the café in the same time period as cases. The other components of the dish were also unlikely to have been vehicles of infection, as the prawns in the dish were made-to-order and fully cooked, the noodles were fried, the seafood bisque was boiled and a sample from the same batch found to be *Salmonella* negative, and the toast was a biologically implausible source and was not eaten by one case.

Further, hollandaise sauce is a well-established high-risk food for *Salmonella* infection[11-12] as it cannot be cooked to a temperature sufficient to kill *Salmonella* bacteria without curdling, and must remain warm or be re-warmed to retain its consistency.

A number of factors that would encourage the contamination and growth of Salmonella in the hollandaise sauce produced by Café X were identified during the environmental investigation. Firstly, the high-risk preparation process of separating the eggs for the sauce using eggshells or hands points to a likely point of contamination for at least one batch of sauce. Then, as the cleaning process for the hollandaise storage and serving siphons was inadequate to sanitise the siphons between batches, this may have led to contamination of subsequent batches of sauce, explaining the extended six day period over which this outbreak occurred. Finally, Café X reported making two batches of hollandaise per day which were decanted into serving siphons and kept in a warm water bath until required for service. They reported discarding any remaining sauce after the breakfast/lunch service period, but as there were no records of batches made on the days in question, it is unclear whether the sauce was always strictly discarded after four hours as per the two hour/four hour guidelines.[10] Leaving the hollandaise sauce in a

warm environment for a number of hours would encourage significant *Salmonella* growth if the sauce was contaminated.

This outbreak highlights issues around the production and serving of high risk foods in restaurant/café settings. Sauces and condiments that contain raw or undercooked eggs (e.g. hollandaise sauce, mayonnaise, or aioli) are often produced and stored until they are served, which can result in large and prolonged outbreaks.[8] Although a food establishment in Victoria such as Café X is required to have a food safety program and a trained food safety supervisor, proper food handling practices may be known but not adhered to, opening pathways for the contamination of food items and the potential to cause illness in large numbers of people. This reinforces the need for all food handlers to understand exactly how and why contamination of foods can occur, and for regular training and reviews of adherence to appropriate food handling procedures to take place.

Ideally, consumers should also be made aware that they are ordering a high-risk food before they choose to consume it. Anecdotally, many cases interviewed during the course of this investigation had limited knowledge of why a hollandaise sauce, as a 'cooked' product, was classified as high risk and how it might become contaminated. One way to increase consumer awareness might be to implement consumer advisory notices for raw or semi-cooked foods on menus, as recommended by the United States Food and Drug Administration Food Code.[13] Another way of minimising the risk of egg-based outbreaks is to encourage the use of pasteurised egg products in raw and undercooked foods served by food premises.[14] As recommend by the local council, Café X took positive action following this outbreak by replacing whole eggs with pasteurised egg product in any uncooked or semi-cooked food items, and removing the implicated meal from its menu.

Limitations

Café X advised that it sold 132 serves of the eggs benedict meal with seafood over three days (and the outbreak took place over six days), so it is likely that the number of cases identified by this investigation greatly underrepresents the number of people affected. However, because there were no booking lists, we were unable to contact everyone who consumed this meal, and it is possible that not every serve was contaminated. The lack of booking lists also meant we were unable to conduct a larger cohort study, but

employing another methodology (e.g. a case control) was deemed unnecessary as the descriptive evidence for the vehicle of infection was so strong. Although the small sample size of the cohort study we did conduct limited its statistical power to test hypotheses, we were still able to obtain a statistically significant finding which supported the descriptive evidence.

Microbiological evidence for the suspected food source (the hollandaise sauce) was not obtained, but this was not unexpected as only a freshly made batch of hollandaise was tested; the siphon had been cleaned in the preceding days; and it is unlikely that more than a few eggs in the batch used to make the hollandaise sauce were contaminated.[15-16] Environmental swabs from the egg farm were also negative for *Salmonella*, but again this was not surprising given that excretion of *Salmonella* in infected chickens can be intermittent, and the egg farm was sampled over a month after the outbreak occurred.[17]

Despite these limitations, this outbreak investigation succeeded in identifying the food vehicle, preventing further illness by removing the food item from sale, and reducing the risk of further outbreaks from this café by instituting effective cleaning processes, amending issues in food handling procedures, and introducing the use of pasteurised eggs in lightly-cooked foods. This outbreak investigation also offered an opportunity to provide both the food establishment and affected customers with a greater knowledge and understanding of *Salmonella* transmission, risk factors, and illness prevention.

Acknowledgments

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Chapter III:
Epidemiological Study

Irritable bowel syndrome and reactive arthritis following an outbreak of *Salmonella* Anatum

Table of Contents

Preface

Background to project

From December 2015 to March 2016 a large outbreak of *Salmonella* Anatum associated with the consumption of bagged salad occurred across Australia. Victorians accounted for 79% of the 311 cases. Having begun my MAE placement with OzFoodNet Victoria in early March 2016, the interviews I conducted as part of this investigation were some of my first. It was suggested by OzFoodNet epidemiologist Joy Gregory that given this outbreak was uncommonly large, it provided an excellent opportunity to conduct an epidemiological study investigating the incidence of sequelae following *Salmonella* infection.

My role

I was the lead investigator on this project and managed all aspects of the study, including development of study documents; gaining ethics approval; mailing study packages; conducting participant follow-up; data entry and management; and data analysis. The study protocol and questionnaire were developed in collaboration with Dr Katherine Gibney, informed by a protocol and questionnaire she had created for a similar study that did not proceed.

Communication

The findings of this study were presented on a number of occasions to different audiences, including:

- An OzFoodNet Face-to-Face meeting (oral presentation)
- An MDU/VIDRL lunchtime seminar held at the Peter Doherty Institute for Infection and Immunity (oral presentation)
- The Communicable Diseases Control Conference (CDCC) 2017 (poster presentation)
- The Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET) 9th Global Scientific Conference 2017 (oral presentation, for which I was awarded 3rd place in the Best Oral Presentation award category)

The oral presentation at the TEPHINET conference fulfilled the MAE program requirement to present at a national or international scientific conference. The slides for this presentation are presented in chapter Appendix 1. The CDCC conference poster is presented in chapter Appendix 2. A summary of results for participants was also developed for this study, fulfilling the MAE program requirement to develop a report to a non-scientific (lay) audience. This summary is presented in chapter Appendix 3.

Lessons learnt

Coordinating this project taught me much in the way of managing a multi-stage study, and provided my first experience in designing study materials. In particular, this project taught me:

- **The difficulty of developing a study in a tight timeframe**: By the time it was decided to undertake this study, we had a very short time in which to design and prepare the study for ethics approval, in order to get the first questionnaire to participants at six months after their *Salmonella* infection. I was extraordinarily lucky that Katherine Gibney had already prepared a similar questionnaire that we could work from, but having more time may have allowed us to craft an online questionnaire, and to pre-contact participants, which may have resulted in a higher response rate. Where possible, designing a study well in advance is recommended!
- **The intricacies of designing an effective questionnaire:** Although our study questionnaire was based on a diagnostic questionnaire and another questionnaire used in a similar study, some participant responses indicated that misunderstanding of questions may have occurred. Having time to thoroughly pilot our questionnaire might have avoided these misunderstandings. Although we also tried to keep the questionnaire as short as possible, it was still relatively long and this may have dissuaded some potential participants. Again, had we had the time, it might have been more effective to send an initial, shorter questionnaire that asked whether the symptoms of interest had been experienced, and if so, ask the participant to complete a more detailed follow-up questionnaire. These lessons will be valuable should this study or a similar one be conducted by the DHHS again.

- **How strenuous, but rewarding, the ethics approval process can be**: As my first experience applying for ethics approval, this project taught me much about reflecting on the work you want to conduct and how it might be perceived and experienced by others. I became familiar not only with the ethics approval process, but with the National Privacy Principles and the different grades of approval required for different studies. This experience will inform how I approach research in the future, and I vow to never leave an ethics application to the last minute ever again!
- **Preparation of conference posters and presentations:** The CDCCC and TEPHINET conferences at which this project was presented in poster and oral presentation form were the first professional conferences I had attended. The process of developing the poster and the oral presentations provided me with valuable experience in clearly and succinctly presenting my work in different formats, to peers of varying language backgrounds.

Public health impact

This study provides the first known information on the incidence and duration of PI-IBS following *Salmonella* infection in Australia, and contributes to limited existing published literature on ReA in Australia. This information can be used to inform more complete estimates of the burden of *Salmonella* in Australia and may help to raise awareness of these conditions in the general public and in primary care physicians, leading to better diagnosis and care. It is also hoped that this study can be used as a template to facilitate further studies into sequelae from enteric infections in the future.

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Special thanks go to Katherine Gibney for all her help and support in developing this study. I would also like to thank and acknowledge:

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- Sherry Rohekar and Robert Inman for kindly sharing with me their AReA questionnaire
- All the study participants who gave their valuable time to contribute to this study

Abstract

Background: *Salmonella* infection can result in short and long-term sequelae including post-infectious irritable bowel syndrome (PI-IBS) and reactive arthritis (ReA). There are limited published studies on the incidence of ReA, and none on the incidence of PI-IBS, following *Salmonella* infection in Australia. The aim of this study was to determine the proportion of Victorian cases associated with a *Salmonella* outbreak that developed symptoms indicative of PI-IBS and/or ReA following their infection.

Methods: Eligible outbreak-associated subjects (>10 years; not pregnant; no additional enteric infections) were mailed a structured questionnaire six months after their infection/illness. The questionnaire collected information on whether subjects experienced symptoms consistent with PI-IBS and/or ReA in the six months after their acute illness/infection. If participants indicated that they were still experiencing ongoing symptoms of interest at the time of completing the first questionnaire, they were sent a second questionnaire 12 months after their infection/illness. This questionnaire collected information on changes and duration of symptoms. Descriptive analyses were conducted using Microsoft Excel and Stata IC 12.1. Fisher exact Chi-squared tests (for binary variables) and Wilcoxon rank sum tests (for continuous variables) were employed to determine associations between the outcome and exposure variables of interest.

Results: 195 subjects (median age: 45 years; 62% female) were invited to participate. Ninety-one cases completed the initial study questionnaire, giving a response rate of 47%. Six of these participants had to be excluded, leaving an overall number of 85 study participants (median age: 51 years; 71% female). Twenty-seven participants (32%) reported new abdominal pain and gastrointestinal symptoms in the six months following their *Salmonella* illness/infection, of whom 15 (18%) met the symptomatic criteria for PI-IBS. Ten participants (12%) reported experiencing new joint symptoms consistent with ReA. Close to 50% of PI-IBS cases, and 56% of ReA cases, were still experiencing these symptoms at 12 months post infection.

Conclusions: This study is the first known investigation into the incidence of PI-IBS following *Salmonella* infection in Australia, and contributes to the limited information on the incidence of ReA following *Salmonella* outbreaks in Australia. The proportions of participants with ReA and PI-IBS symptoms are comparable with other studies, but the

potential influence of selection bias, recall bias, and/or the inaccuracy of self-reporting is recognised. This study contributes important local information that can be used to inform more complete estimates of the burden of *Salmonella* in Australia, and improve post-infection diagnosis and care by primary care physicians.

Introduction

Salmonella is a significant cause of gastrointestinal disease in Australia. Of the 40,367 cases of gastrointestinal disease notified to the Australian National Notifiable Diseases Surveillance System (NNDSS) in 2014, *Salmonella* notifications accounted for 41% (16,358 notifications).[1] Further, the incidence of *Salmonella* has continued to rise in recent years, with the number of cases notified in 2014 representing a 42% increase on the 5 year mean, and the highest number of cases since reporting to the NNDSS began in 1991.[1] This pattern is reflected in the Australian state of Victoria, which in 2016 reported 4089 cases of *Salmonella* infection, representing an increase of 33% on the Victorian 5 year mean.[2]

Salmonellosis is characterised by the rapid development of gastrointestinal symptoms (including abdominal pain, diarrhoea, fever, muscle pain, nausea and/or vomiting) that are usually self-limiting. However, symptoms can range from none (asymptomatic cases) to serious manifestations that require hospitalisation and can be potentially fatal.[1,3] Additionally, persons who have been infected with *Salmonella* can develop post-infection sequelae that can become chronic, lasting from months to years. Sequelae most commonly associated with *Salmonella* infection are post-infectious irritable bowel syndrome (PI-IBS) and reactive arthritis (ReA).[4]

Irritable bowel syndrome (IBS) is a functional bowel disorder with chronic, episodic symptoms of altered bowel habits and abdominal pain or discomfort.[5] The prevalence of IBS among Australian adults is estimated at 10%, and it affects twice as many females as males.[6] Among both children and adults, IBS has been associated with decreased quality of life, increased prevalence of psychosocial disorders, increased medication use, more frequent absences from school and work, and significant direct and indirect economic costs.[7] IBS has been found to develop in a proportion of people following episodes of acute gastroenteritis (AGE), a condition referred to as post-infectious IBS (PI-IBS).[5] Individual studies report that between 3.7%–36% of *Salmonella* AGE cases go on to develop PI-IBS,[8] while systematic reviews have found pooled estimates of between 3-10%.[4,9-10]

ReA is an immune-mediated arthritis usually triggered by a gastrointestinal or genitourinary tract infection that can also be accompanied by a range of extra-articular

symptoms.[11] Annual incidence estimates from population studies vary from 0.6–27/100,000 in the general population,[12] though studies following *Salmonella* outbreak cohorts have found the incidence of symptoms consistent with ReA to be between 8-62.5%.[13-21]

The pathogenesis of these conditions is still undefined, but fundamentally both are suspected to stem from a protracted immune response and the associated inflammation, with certain genetic susceptibilities also implicated in the development of ReA.[8,11,22-23] These sequelae contribute significantly to the overall burden of *Salmonella* infections in the community, with studies indicating that especially in developed countries where fatalities due to AGE are rare, sequelae contribute more to the greater burden of these diseases than the acute illness/infection does.[24-25]

As the incidence of *Salmonella* infection in Australia increases, it can be expected that the incidence of chronic sequelae following these infections will also increase. As such, it is important to understand the incidence, expression, and duration of sequelae following *Salmonella* infection in Australia, so that more accurate estimates of the burden of this disease can be made to inform health policy, and so that the general public and health care providers have relevant information for better health outcomes. Studies investigating the development of ReA following *Salmonella* infection in Australia are limited,[20-21] and no Australian studies have yet been published investigating the development of PI-IBS. Consequently, published estimates of the burden of *Salmonella* and its sequelae in the Australian population have relied heavily on incidence and duration findings from international studies.[24,26]

This study of *Salmonella* cases from a recent outbreak in Victoria, Australia, aimed to:

- determine the proportion of *Salmonella* cases who developed transient or chronic symptoms consistent with PI-IBS and/or ReA following their infection;
- characterise these symptoms by duration and severity; and
- identify risk factors for the development of these conditions.

Methods

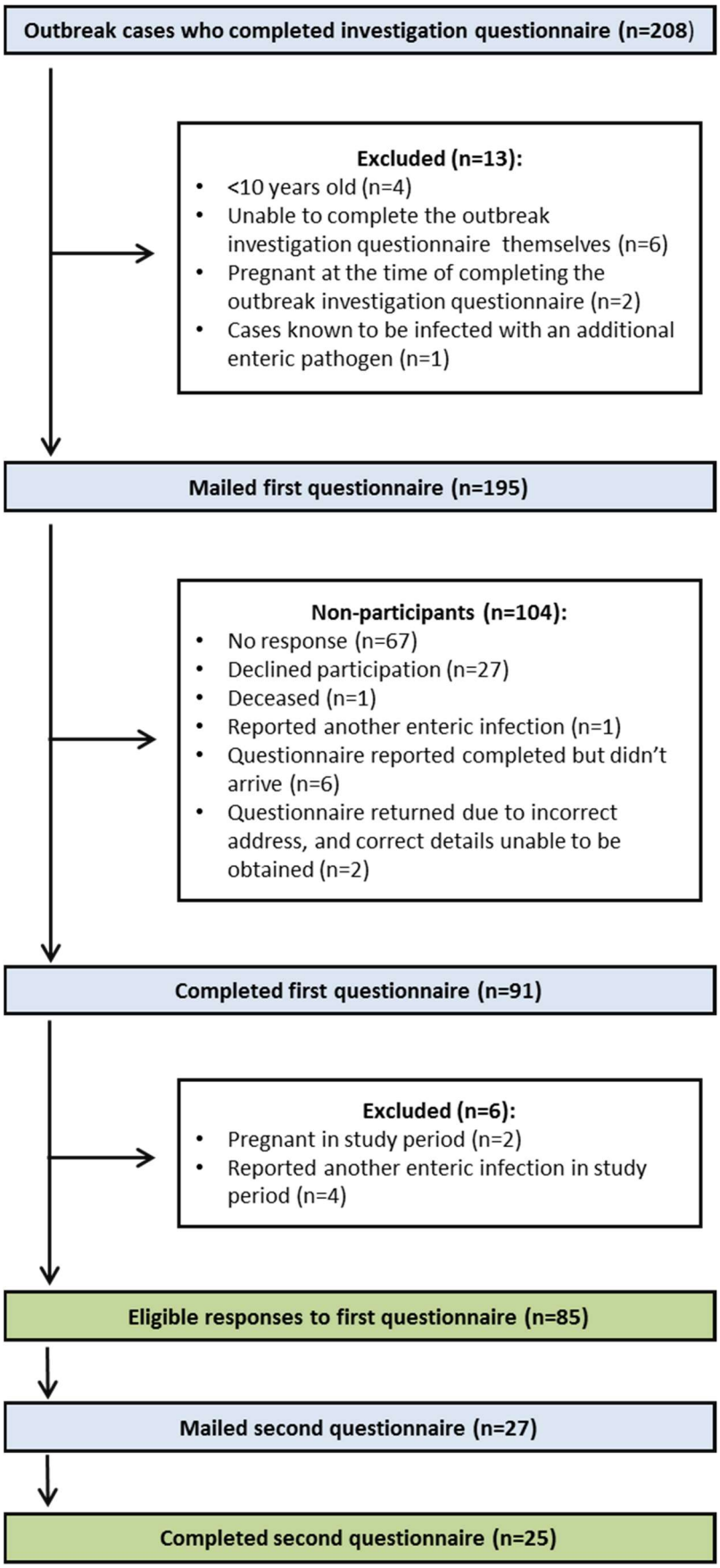
Study population

From December 2015 to March 2016 an outbreak of *Salmonella* Anatum associated with the consumption of bagged salad occurred across Australia. Victorian residents accounted for 79% of the 311 cases. During the outbreak investigation Victorian cases who were notified to the Victorian Department of Health and Human Services (DHHS) were asked to complete a standardised questionnaire, detailing their illness and what foods they had consumed in the week before illness onset. Cases who completed an outbreak investigation questionnaire were assessed for eligibility to participate in this study.

Cases were deemed ineligible to participate in this study if they were under ten years old; had required someone else to complete the outbreak investigation questionnaire on their behalf; were noted to have had difficulty completing the outbreak investigation questionnaire due to language barriers; were pregnant at the time of infection; or who had laboratory-confirmation of infection with another enteric pathogen either at the time of *Salmonella* infection or between that time and the commencement of the study (Figure 1). The rationale for these exclusion criteria are as listed below:

- Children <10 years: It was assumed that young children, and consequently their parent/guardian, would not have the ability to accurately articulate and/or recall the detailed information required for this study.
- Those unable to complete the outbreak investigation questionnaire themselves, or had difficulty completing the questionnaire due to language barriers: These cases might have had difficulty completing and/or interpreting the detailed study questionnaire, and asking them to complete it may have caused them undue inconvenience or distress.
- Pregnant women: pregnancy is known to impact both joint and gastrointestinal health[27-28], so symptoms of interest experienced by pregnant participants could be masked, enhanced, or caused by the pregnancy.

Figure 1: Study participant flowchart



- Other enteric infections: other enteric infections are also known to be associated with the symptoms of interest,[8,23] so it would be impossible to determine which symptoms were attributable to sequelae following salmonellosis.

Study design

In this prospective cohort study, all eligible cases were invited to complete a questionnaire six months following their *Salmonella* infection (between July and October 2016). Eligible cases were mailed a package containing an invitation letter, information about the study, and the first study questionnaire (Appendices 4-6). For those cases under the age of 18, this package was addressed to their parent/guardian, and it was suggested that where possible the child complete the questionnaire, with parental supervision if required.

The first questionnaire collected information on what medical care and treatment the participant accessed for their initial *Salmonella* infection; whether prior to their infection the participant had been diagnosed with IBS, inflammatory bowel disease (IBD), or arthritis; whether the participant had experienced symptoms of PI-IBS and/or ReA in the six month period since their acute illness/infection; whether these symptoms were new (only experienced after their *Salmonella* infection) or existing; and a detailed characterisation of these symptoms, including location, duration, and severity (measured by whether medication was required to relive symptoms and/or whether symptoms impacted on the ability of the participant to complete usual daily activities) (Appendix 6). Consent was also sought to send the participant the second questionnaire if relevant.

The study questionnaire was individualised to include a reminder of the end date of symptoms reported by the case in the initial outbreak investigation questionnaire to orient the case to the period of interest to the study (the 6 month period after acute illness/infection). Where the end date of symptom duration was not provided in the outbreak investigation questionnaire (due to ongoing symptoms or no symptoms) the date of the last positive laboratory result was used as a proxy to mark the beginning of the study period of interest. Study questionnaires did not collect any identifying information from participants, but a study participant number between the value of 001

and 197 was randomly assigned to each case to enable participants to be re-identified by the study investigators.

Cases who returned a completed questionnaire were considered to have consented to participate in the study. If cases did not wish to participate in the study they were asked to return a blank questionnaire in the reply envelope provided, or to contact the study investigators to decline participation. If the questionnaire was not returned or a phone call or email had not been received in the month after the study package was sent, the study investigators attempted to contact participants by telephone on a maximum of two occasions, and to resend the invitation letter and questionnaire package once more. Participants were classified as withdrawn if they registered their withdrawal as above or if they did not respond to the questionnaire or associated follow-up efforts.

A subset of participants who reported any ongoing gastrointestinal or rheumatological symptoms at the time they completed the first questionnaire were invited to complete a second questionnaire at 12-months following their *Salmonella* infection (between January and April 2017). The second questionnaire aimed to determine whether the symptoms reported in the first questionnaire were still present, and if so, to characterise any changes in those symptoms over the previous six months. The second questionnaire was only sent if the participant had consented for it to be sent in the first questionnaire. The second questionnaire was individualised for each eligible participant, as it referred to the specific symptoms reported by the participant in the first questionnaire (Appendix 7). The questionnaire listed these symptoms and asked which were still present (and if not present, when they ceased); whether and how these symptoms had changed in the past 6 months; what medical care had been sought to address them; and whether these symptoms had impacted on the participant's ability to undertake daily activities.

Data management

Data were collected on paper based questionnaires either returned by mail or completed through telephone interview. Questionnaires were checked for completeness and validity and, if necessary, follow-up was undertaken to correct and complete questionnaire responses. Final data were entered into a Microsoft Access database and exported to Microsoft Excel and Stata IC 12.1 (StataCorp, 2011. College Station, Texas) for analysis. To facilitate accurate management of participant records, a

Microsoft Excel list was created to link de-identified participant study numbers to identifying participant information. On completion of data analysis, this file was destroyed so that no records remained to identify study participants.

Case definitions

PI-IBS

Participants were considered to have symptoms consistent with PI-IBS if these symptoms occurred in the first 3 months after the initial *Salmonella* illness/infection, were present for at least 3 months, and met the Rome IV criteria for IBS:

Recurrent abdominal pain (at least weekly) associated with two or more of the following criteria:

- Related to defecation (at least 30% of occasions)
- Associated with a change in frequency of stool (at least 30% of occasions)
- Associated with a change in form (appearance) of stool (at least 30% of occasions)

ReA

Participants were considered to have symptoms consistent with ReA if they experienced onset of new pain, swelling, or reduced movement in at least one joint in the first 3 months after the initial *Salmonella* illness/infection.

Data analysis

Descriptive analyses were conducted using Microsoft Excel and Stata IC 12.1. Fisher exact Chi-squared tests (for binary variables) and Wilcoxon rank sum tests (for continuous variables) were employed to determine associations between the outcome and exposure variables of interest. Analyses were conducted separately for the outcomes of PI-IBS and ReA. Exposures of interest (independent variables) included age, sex, symptoms of initial infection, diarrhoea duration, healthcare accessed for initial infection, and use of antimicrobial treatment for initial infection. Participants who reported symptoms of each study outcome (PI-IBS or ReA) prior to their *Salmonella* infection were excluded from the corresponding analyses: participants who reported gastrointestinal conditions diagnosed prior to their *Salmonella* infection or an

exacerbation of gastrointestinal symptoms experienced prior to their *Salmonella* infection were excluded from the PI-IBS analysis, and participants who reported exacerbation of pre-existing joint symptoms or arthritis diagnosed prior to their *Salmonella* infection were excluded from the ReA analysis. Differences at 5% level were considered statistically significant.

Study participants were compared to non-participants using the Fisher exact Chi-squared test (sex and symptom duration of diarrhoea) and the Wilcoxon rank sum test (age).

Ethics

This study was approved by the Victorian DHHS Human Research Ethics Committee (HREC) (project number 10/16) and the Australian National University HREC (project number 2016/341).

Results

Study participants

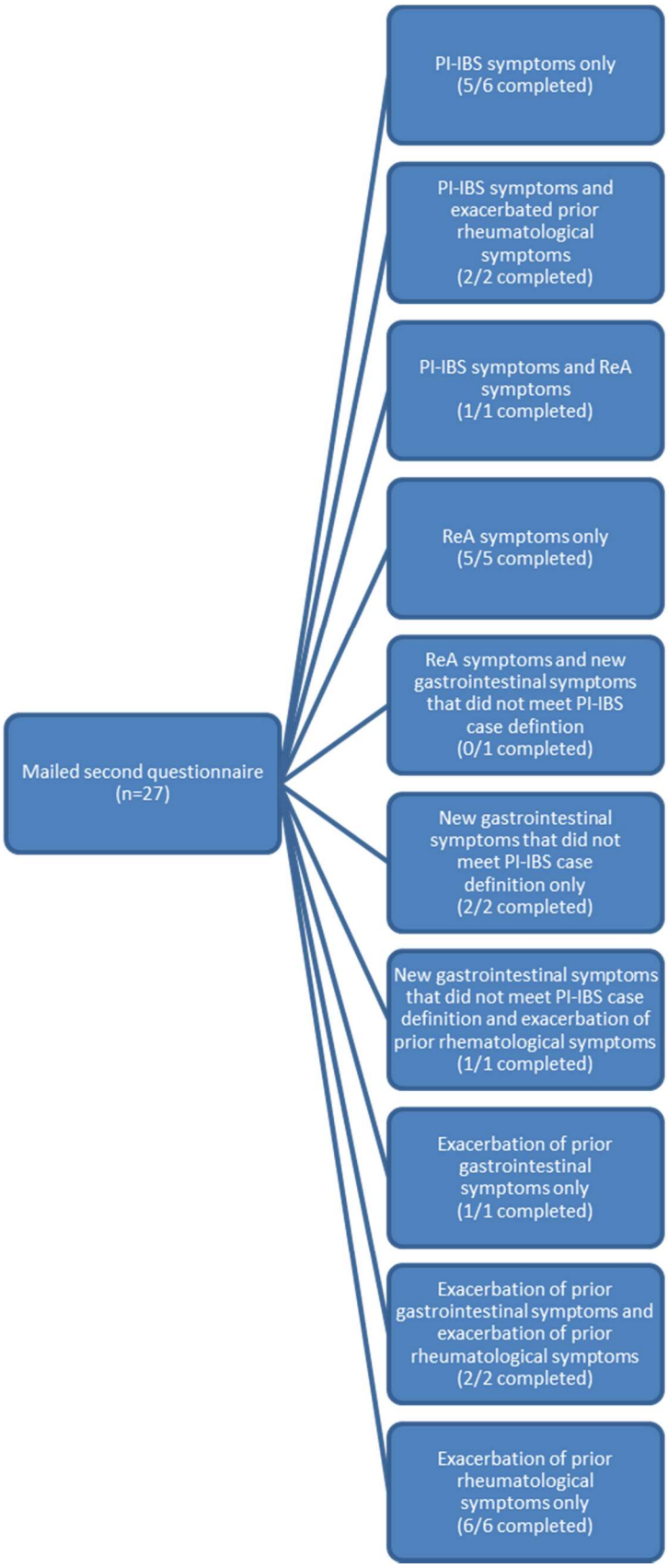
The recruitment of study participants is detailed in Figure 1. Of the 208 cases interviewed in the outbreak investigation, 195 were eligible to be invited to participate in the study. Ninety-one cases completed the initial study questionnaire, giving a response rate of 47%. Six of these participants had to be excluded due to pregnancy or another enteric infection, leaving an overall number of 85 study participants (Figure 1).

Twenty-seven of these participants were eligible and consented to receive the second questionnaire, of whom 25 participated (response rate 93%) (Figure 2). Participants were predominantly female (71%) and had a median age of 51 years (range 11-85 years) (Table 1).

Table 1: Demographics of participants, non-participants, and entire cohort

Study Group	Proportion female	Median age (range)
Whole study cohort n=195	62%	45 (10-91)
Non-participants n=104	55%	41.5 (10-91)
Eligible participants n=85	71%	51 (11-85)

Figure 2: Participants who reported ongoing symptoms of interest at six months post *Salmonella* infection who were sent the second questionnaire (n=27)



PI-IBS

In total, 27/85 participants (32%) experienced new abdominal pain and other gastrointestinal symptoms in the first six months following their acute *Salmonella* illness/infection. Fifteen of these participants met the case definition for PI-IBS; a total of 18% of eligible participants (15/85). Those with PI-IBS symptoms had a median age of 63 years (range 11-77 years) and 60% were female. All 15 PI-IBS cases experienced abdominal pain at least weekly and their recurrent abdominal pain was both related to defecation and associated with a change in form of stool. The majority of PI-IBS cases reported that abdominal pain was associated with a change in stool frequency (93%), and reported more frequent stools (93%) and looser stools (87%) (Table 2).

Table 2: Symptoms experienced by PI-IBS cases in the first three months after infection (n=15)

PI-IBS symptoms	Participants (%)*
Recurrent abdominal pain	15 (100)
Pain related to defecation	15 (100)
Pain associated with change in frequency of stool	14 (93)
More frequent bowel motions	14 (93)
Less frequent bowel motions	3 (20)
Pain associated with change in form of stool	15 (100)
Looser stools	13 (87)
Harder stools	4 (27)

*Proportions equate to more than 100% as some participants experienced both more and less, and/or looser and harder, stools at various times

Close to 50% of PI-IBS cases (7/15) were still experiencing these symptoms at 12 months post infection (Table 3). The second questionnaire was not returned by one eligible participant, so their known duration of symptoms was six months.

Table 3: Duration of PI-IBS symptoms for PI-IBS cases (n=15)

Duration of symptoms	Participants (%)
3-4 months	4 (27)
5-6 months	3 (20)*
7-8 months	-
9-10 months	1 (7)
11-12 months	-
>12 months	7 (47)

*Second questionnaire not returned by one case. Six months last known duration.

To assess changes in symptoms the first questionnaire was split into two three month periods, together comprising the initial six month period after illness/infection. Table 2 above represents symptoms reported in the first three months after illness/infection.

Table 4 details the changes in those symptoms in the second three month period. Two participants experienced no change in their symptoms and the majority (8/15, 53%) experienced no alteration to the change in the form of their stool. However, many (7/15, 47%) did report that their abdominal pain became less frequent. Consequently, if the PI-IBS case definition was applied again to symptoms reported in the second three months, three PI-IBS cases would no longer meet the case definition as their abdominal pain was no longer experienced weekly. However, these participants all still experienced at least two of the other required symptoms on at least 30% of occasions and, for the purposes of this study, once the case definition for PI-IBS symptoms was met, cases were considered to continue to meet the definition of a PI-IBS case until they reported no longer experiencing any altered gastrointestinal symptoms.

Table 4: Changes in symptoms experienced by PI-IBS cases from first three months to second three months from *Salmonella* infection (n=15)

Change in second 3 months	Participants (%)
No change in symptoms at all	2 (13)
No change abdominal pain	8 (53)
Abdominal pain less common	7 (47)
Abdominal pain more common	-
No change in bowel movement frequency	5 (33)
More frequent bowel movements less common	5 (33)
More frequent bowel movements more common	1 (7)
Less frequent bowel movements less common	3 (20)
Less frequent bowel movements more common	3 (20)
No change in stool form	8 (53)
Softer than usual form less common	4 (27)
Softer than usual form more common	2 (13)
Harder than usual form less common	3 (20)
Harder than usual form more common	1 (7)

Nine PI-IBS cases reported in the first questionnaire that their PI-IBS symptoms were still ongoing, so were sent the second questionnaire 12 months after their *Salmonella* infection. Eight PI-IBS cases completed the second questionnaire (Figure 2). Responses from the second questionnaire described any further changes in symptoms experienced in this second six month period. The majority of those still experiencing symptoms at 12 months were experiencing fewer symptoms than in the first six months after infection and either experienced no change or a lessening of symptom severity and frequency (Table 5).

Table 5: Change in symptoms in the second six months from *Salmonella* infection for PI-IBS cases who were sent and completed the second questionnaire (n=8)

Change in second 6 months	Participants (%)
No longer experiencing symptoms	**1 (13)**
No change in symptoms at all	**2 (25)**
No change in symptom profile	-
Experiencing fewer symptoms	5 (63)
Experiencing more symptoms	-
No change in symptom severity	3 (38)
Symptoms less severe	2 (25)
Symptoms more severe	-
No change in symptom frequency	3 (38)
Symptoms less frequent	2 (25)
Symptoms more frequent	-

Two thirds of PI-IBS cases (10/15) visited a GP in relation to their symptoms in the first six months and 47% (7/15) saw multiple healthcare providers (Table 6). Sixty per cent of PI-IBS cases (9/15) took medication to relieve their symptoms (including antidiarrheal and anticholinergic medications, painkillers, and proton pump inhibitors), and the symptoms experienced by 40% (6/15) of PI-IBS cases affected their ability to undertake usual daily tasks on at least one occasion. These findings were reflected to a slightly lesser extent in those PI-IBS cases whose symptoms lasted longer than six months, with almost 40% (3/8) seeing a GP and taking medication to relieve symptoms in the second six month period after *Salmonella* infection. Four PI-IBS cases reported being diagnosed with IBS in the first six months after their *Salmonella* infection, and one additional person was diagnosed with IBS in the second six month period.

Table 6: Healthcare accessed and markers of symptom severity reported by PI-IBS cases in the first questionnaire (n=15) and in the second questionnaire (n=8)

Severity markers	0-6 months after *Salmonella* infection (%) (n=15)	7-12 months after *Salmonella* infection (%) (n=8)
Saw a GP	10 (67)	3 (38)
Saw a specialist (outpatient)	5 (33)	2 (25)
Went to emergency	3 (20)	1 (13)
Was admitted to hospital	2 (13)	1 (13)
Other health care	1 (1)	1 (13)
Multiple health care providers	7 (47)	2 (25)
Took medication to relive symptoms	9 (60)	3 (38)
Symptoms affected ability to undertake daily tasks (at least once)	6 (40)	2 (25)
Participant diagnosed with irritable bowel syndrome (IBS)	4 (27)	1 (13)

The only exposure variable significantly associated with developing symptoms of PI-IBS was having seen a medical specialist as an outpatient for the initial *Salmonella* infection (Table 7). The effect of duration of diarrhoea associated with the acute salmonellosis was difficult to examine because this information was only available for seven of the 15 PI-IBS cases and 26 of the 35 non-cases.

Table 7: Analysis of association between illness variables and development of PI-IBS symptoms

Exposure variable	Number PI-IBS cases*	Number non-cases*	*P* value for test of association**
Demographics			
Age	Median 63 (range 11-77, IQR 30)	Median 53 (range 19-88, IQR 26)	**0.742**
Sex	60% female (9/15)	66% female (23/35)	**0.754**
Symptoms associated with *Salmonella* infection			
Diarrhoea ≥ 1 week	**71% (5/7)**	**46% (12/26)**	**0.398**
Yes	5	12	
No	2	14	
Unknown	*8*	*9*	
Fever	**46% (6/13)**	**50% (16/32)**	**1.000**
Yes	6	16	
No	7	16	
Unknown	*2*	*3*	
Nausea	**60% (9/15)**	**68% (23/34)**	**0.747**
Yes	9	23	
No	6	11	
Unknown	*0*	*1*	
Vomiting	**13% (2/15)**	**26% (9/35)**	**0.468**
Yes	2	9	
No	13	26	
Unknown	*0*	*0*	
Abdominal cramping	**80% (12/15)**	**80% (28/35)**	**1.000**
Yes	12	28	
No	3	7	
Unknown	*0*	*0*	
Blood in stool	**7% (1/15)**	**6% (2/35)**	**1.000**
Yes	1	2	
No	14	33	
Unknown	*0*	*0*	
Muscle ache	**39% (5/13)**	**64% (21/33)**	**0.187**
Yes	5	21	
No	8	12	
Unknown	*2*	*2*	
Headache	**53% (8/15)**	**53% (17/32)**	**1.000**
Yes	8	17	
No	7	15	
Unknown	*0*	*3*	
Healthcare accessed for *Salmonella* infection			
No medical care accessed	**- (0/15)**	**11%(4/35)**	**0.302**
Yes	0	4	
No	15	31	
Unknown	*0*	*0*	
GP care	**93% (14/15)**	**80% (28/35)**	**0.407**
Yes	14	28	
No	1	7	

Unknown	*0*	*0*	
Outpatient specialist care	**20% (3/15)**	**- (0/35)**	**0.023**
Yes	3	0	
No	12	35	
Unknown	*0*	*0*	
Emergency visit	**13% (2/15)**	**11% (4/35)**	**1.000**
Yes	2	4	
No	13	31	
Unknown	*0*	*0*	
Hospital Admission	**13% (2/15)**	**9% (3/35)**	**0.629**
Yes	2	3	
No	13	32	
Unknown	*0*	*0*	
Took antibiotics	**39% (5/13)**	**45% (9/29)**	**0.729**
Yes	5	9	
No	8	20	
Unknown	*2*	*6*	

* Unless otherwise specified

**Chi-squared Fisher exact test for binary variables, Wilcoxon Rank Sum test for continuous variable (Age)

New gastrointestinal symptoms not meeting the PI-IBS case definition

Twelve participants (14%, 12/85) developed new gastrointestinal symptoms that did not meet the case definition for PI-IBS. Three quarters of these participants (9/12) did not meet the case definition because they experienced abdominal pain too infrequently (less than weekly). The remaining three experienced symptoms for less than three months. The majority of these participants experienced softer than usual bowel motions (92%, 11/12) and more frequent than usual bowel motions (67%, 8/12). Four of these participants were still experiencing these new gastrointestinal symptoms six months after their *Salmonella* infection, and received the second questionnaire. Three of these four participants completed the second questionnaire. Two were still experiencing these gastrointestinal symptoms 12 months after their *Salmonella* infection, while the third participant reported they did not know if they were still experiencing these symptoms. One of the two participants still experiencing symptoms at 12 months reported their symptoms were less frequent, while the other reported their symptoms were more frequent but less severe.

Exacerbation of prior gastrointestinal symptoms

Sixteen of the 85 study participants (19%) who reported that they had experienced gastrointestinal symptoms in the six months after their infection, also reported that they had experienced these symptoms prior to their *Salmonella* infection. Ten of these

participants (12%, 10/85) reported that these prior gastrointestinal symptoms were noticeably exacerbated. Only one of these ten participants was still experiencing exacerbated gastrointestinal symptoms at 12 months post infection, while 30% of cases (3/10) only experienced worsened symptoms for 1-2 months post infection (Table 14). The entire duration of symptoms is not known for one participant who did not consent to being sent the second questionnaire, and two cases who received the second questionnaire did not know if their symptoms were still worse at that time. Consequently, these cases were also unable to report whether their symptoms had changed in the second six month period. The one case who was still experiencing exacerbated prior symptoms 12 months after their *Salmonella* infection reported that they were experiencing fewer exacerbated symptoms, but that those symptoms they were still experiencing had not changed in severity.

Table 14: Duration of exacerbated gastrointestinal symptoms (n=10)

Duration of symptoms	Participants (%)
Under one month	1 (10)
1-2 months	3 (30)
3-4 months	-
5-6 months	5 (50)*
7-8 months	-
9-10 months	-
11-12 months	-
>12 months	1 (10)

*Six months last known duration for 3 cases without further duration information

ReA

Nine participants (11%, 9/85) reported experiencing new joint symptoms that met the case definition for ReA. These respondents had a median age of 46 years (range 34-63 years) and all were female. Joint symptoms were oglioarticular (affecting one to four joints) in four of the nine cases, and two each experienced monoarticular and polyarticular symptoms (symptoms affecting one joint and five or more joints respectively). One case did not state in how many joints or where they experienced symptoms. Of the eight cases who reported symptom location, fingers and ankles were most commonly affected, followed by knees, toes, shoulders, and the lower back (Table 8).

Table 8: Location of symptoms reported by ReA cases (n=9)

Location of symptoms	Participants (%) (n=9)
Ankle	3 (33)
Fingers	3 (33)
Hip	1 (11)
Jaw	1 (11)
Knee	2 (22)
Lower back	2 (22)
Shoulder	2 (22)
Toes	2 (22)
Not stated	1 (11)
Multiple sites	6 (66)
Both sides of body	5 (55)

Five participants with ReA symptoms (56%, 5/9) also reported experiencing associated extraarticular symptoms, with heel pain and ocular symptoms the most commonly reported (Table 9).

Table 9: Extraarticular symptoms experienced by ReA cases (n=9)

Extraarticular symptoms	Participants (%)
Heel pain	3 (33)
Red, itchy, or burning eyes	2 (22)
Rash on genitals	1 (11)
Multiple extra-articular symptoms	1 (11)
No extra-articular symptoms	4 (44)

The majority of ReA cases (56%, 5/9) were still experiencing these symptoms at 12 months post infection (Table 10). The second questionnaire was not returned by one eligible participant, so their known duration of symptoms was six months.

Table 10: Duration of ReA symptoms for ReA cases (n=9)

Duration of symptoms	Participants (%)
Under one month	2 (22)
1-2 months	-
3-4 months	-
5-6 months	1 (11)*
7-8 months	-
9-10 months	1 (11)
11-12 months	-
>12 months	5 (56)

*Second questionnaire not returned by one case. Six months last known duration

ReA symptoms were only assessed for change in those who experienced symptoms for more than six months. Responses to the second questionnaire from the six ReA cases

that completed it revealed that one participant was no longer experiencing symptoms, and that one experienced no change in symptoms at all. Among the remaining four ReA cases, changes to symptom distribution and severity were evenly divided between no change and either an increase or decrease in symptom expression (Table 11).

Table 11: Change in ReA symptoms from the first six months to the second six month period from *Salmonella* infection for ReA cases who completed the second questionnaire (n=6)

Change in second 6 months	Participants (%) (n=6)
No longer experiencing symptoms	1 (17)
No change in symptoms at all	1 (17)
No change in symptom distribution	2 (33)
Experiencing fewer symptoms	-
Experiencing more symptoms	2 (33)
No change in symptom severity	2 (33)
Symptoms less severe	2 (33)
Symptoms more severe	-

The majority of ReA cases in both the first six month period (77%, 7/9) and the second six month period (83%, 5/6) took medication to relieve their symptoms (Table 12), which were predominantly analgesic and anti-inflammatory medications. A large proportion saw a GP for their symptoms in the first six months (44%, 4/9), and in the second six months (67%, 4/6). Only one case in each six month period was affected in their ability to undertake their usual daily tasks, and only one case was diagnosed with a new arthritic condition in the six months following their *Salmonella* infection (Table 12).

Table 12: Healthcare accessed and markers of ReA symptom severity reported by ReA cases in the first questionnaire and in the second questionnaire

Severity marker	0-6 months after *Salmonella* infection (%) (n=9)	7-12 months after *Salmonella* infection (%) (n=6)
Saw a GP	4 (44)	4 (67)
Saw a specialist (outpatient)	-	-
Went to emergency	-	-
Was admitted to hospital	-	-
Other health care	2 (22)	1 (17)
Multiple health care providers	-	1 (17)
Took medication to relive symptoms	7 (77)	5 (83)
Symptoms affected ability to undertake daily tasks (at least once)	1 (11)	1 (17)
Was subsequently diagnosed with an arthritic condition	1 (11)	-

No association between exposure variables of interest and the development of ReA symptoms were found to be statistically significant, though taking antibiotics for the initial *Salmonella* infection came close to significance (Table 13). Again, the effect of symptom duration was difficult to examine because this information was only available for six of the nine ReA cases, and 27 of the 45 non-cases.

Table 13: Analysis of association between illness variables and development of ReA symptoms

Exposure variable	Number ReA cases*	Number non-cases*	*P* value for test of association**
Demographics			
Age	Median 46 (range 34-63 , IQR 15)	Median 44 (range 11-83, IQR 20)	**0.618**
Sex	100% female (9/9)	69% female (31/45)	**0.092**
Symptoms associated with *Salmonella* infection			
Diarrhoea ≥ 1 week	**50% (3/6)**	**52% (14/27)**	**1.000**
Yes	3	14	
No	3	13	
Unknown	*3*	*18*	
Fever	**56% (5/9)**	**46% (18/39)**	**0.719**
Yes	5	18	
No	4	21	
Unknown	*0*	*6*	
Nausea	**67% (6/9)**	**55% (24/44)**	**0.715**
Yes	6	24	
No	3	20	
Unknown	*0*	*1*	
Vomiting	**11% (1/9)**	**16% (7/45)**	**1.00**
Yes	1	7	
No	8	38	
Unknown	*0*	*0*	
Abdominal cramping	**67% (6/9)**	**82% (37/45)**	**0.367**
Yes	6	37	
No	3	8	
Unknown	*0*	*0*	
Blood in stool	**11% (1/9)**	**9% (4/43)**	**1.000**
Yes	1	4	
No	8	39	
Unknown	*0*	*2*	
Muscle ache	**75% (6/8)**	**55% (23/42)**	**0.441**
Yes	6	23	
No	2	19	
Unknown	*1*	*3*	
Headache	**44% (4/9)**	**50% (20/40)**	**1.000**
Yes	4	20	
No	5	20	
Unknown	*0*	*5*	
Healthcare accessed for *Salmonella* infection			
No medical care accessed	**- (0/9)**	**11% (5/45)**	**0.576**
Yes	0	5	
No	9	40	
Unknown	*0*	*0*	
GP care	**100% (9/9)**	**79% (34/43)**	**0.33**
Yes	9	34	
No	0	9	
Unknown	*0*	*2*	
Outpatient specialist care	**- (0/9)**	**7% (3/43)**	**1.000**
Yes	0	3	
No	9	40	

Unknown	*0*	*2*	
Emergency visit	**33% (3/9)**	**12% (5/43)**	**0.130**
Yes	3	5	
No	6	38	
Unknown	*0*	*2*	
Hospital Admission	**11% (1/9)**	**12% (5/43)**	**1.000**
Yes	1	5	
No	8	38	
Unknown	*0*	*2*	
Took antibiotics	**67% (6/9)**	**32% (13/41)**	**0.067**
Yes	6	13	
No	3	28	
Unknown	*0*	*4*	

* Unless otherwise specified

**Chi-squared Fisher exact test for binary variables, Wilcoxon Rank Sum test for continuous variable (Age)

Exacerbation of prior joint symptoms

Twenty-five of the 85 study participants (29%) who experienced joint symptoms in the six months after their infection also reported experiencing these symptoms prior to their *Salmonella* infection. Eighteen of these participants (21%, 18/85) reported that these prior joint symptoms were noticeably exacerbated. Nine of these 18 participants (50%) were still experiencing exacerbated joint symptoms at 12 months post infection (Table 15). One case who received the second questionnaire reported that they did not know if their symptoms were still worse at that time. Of the nine cases who reported still having worsened joint symptoms 12 months after their *Salmonella* infection, the majority (56%, 5/9) reported no change in their exacerbated symptoms. Of the remaining four cases, two reported no change in their symptom distribution and two reported an increase in the number of symptoms experienced. One case reported no change in symptom severity while three reported that their symptoms had become more severe.

Table 15: Duration of exacerbated joint symptoms (n=18)

Duration of symptoms	Participants (%)
Under one month	1 (6)
1-2 months	2 (11)
3-4 months	2 (11)
5-6 months	3 (17)*
7-8 months	-
9-10 months	1(6)
11-12 months	-
>12 months	9 (50)

*Once case not sure of symptom duration. Six months last known duration

Participants with multiple symptoms of interest

Fifteen of the 85 study participants (18%) reported experiencing multiple symptoms of interest in the six months following their *Salmonella* infection (Table 16).

Table 16: Number of participants who reported experiencing each combination of study symptoms of interest

Symptoms of interest	Number of participants (%)
PI-IBS only	9 (11)
PI-IBS and exacerbated prior joint symptoms	5 (6)
PI-IBS and ReA	1 (1)
ReA	5 (6)
ReA and new GI symptoms not meeting PI-IBS criteria	2 (2)
ReA and exacerbated prior GI symptoms	1 (1)
New GI symptoms not meeting PI-IBS criteria only	8 (9)
New GI symptoms not meeting PI-IBS criteria and exacerbated prior joint symptoms	2 (2)
Exacerbation of prior GI symptoms only	6 (7)
Exacerbation of prior GI symptoms and exacerbation of prior joint symptoms	4 (5)
Exacerbation of prior joint symptoms only	7 (8)
Total eligible participants with symptoms of interest	**50 (59)**
Total eligible participants with multiple symptoms of interest	**15 (18)**
Eligible participants with no symptoms of interest	**35 (41)**
Total eligible participants	**85 (100)**

One participant reported developing symptoms that met the case definitions for both PI-IBS and ReA. Their PI-IBS symptoms lasted for 9-10 months, but they continued to experience ReA symptoms 12 months after their *Salmonella* infection. Five PI-IBS cases also reported experiencing exacerbated prior joint symptoms, with two of these cases still experiencing both sets of symptoms 12 months after their *Salmonella* infection.

One ReA case reported experiencing an exacerbation of pre-existing gastrointestinal symptoms. Their ReA symptoms were still present 12 months after their *Salmonella* infection, but they only experienced exacerbated gastrointestinal symptoms for one-two months after their infection. A further two ReA cases experienced new gastrointestinal symptoms that did not meet the case definition for PI-IBS. One of these cases reported still experiencing both ReA and gastrointestinal symptoms six months after their *Salmonella* infection but did not return the second questionnaire. The other case was still experiencing ReA symptoms 12 months after their *Salmonella* infection, but only experienced the new gastrointestinal symptoms for one-two months.

Two cases reported experiencing new gastrointestinal symptoms that did not meet the case definition for PI-IBS and exacerbated prior joint symptoms. One of these cases only experienced these new gastrointestinal symptoms for one-two weeks and exacerbated joint symptoms for one-two months. The other case was still experiencing both joint and gastrointestinal symptoms six months after their *Salmonella* infection, but reported in the second questionnaire that they did not know if they were still experiencing either of these symptoms at that time.

Four participants reported experiencing both exacerbated gastrointestinal symptoms and exacerbated joint symptoms. The first of these cases reported experiencing exacerbated prior joint symptoms for five to six months after their *Salmonella* infection, and reported still experiencing exacerbated prior gastrointestinal symptoms at the time they completed the first questionnaire, but did not consent to being sent the second questionnaire. The second case experienced exacerbated prior joint symptoms for only one to two weeks, and exacerbated gastrointestinal symptoms for five to six months. The third case was still experiencing exacerbated prior joint symptoms 12 months after their *Salmonella* infection, but did not know if they were still experiencing exacerbated prior gastrointestinal symptoms at that time, and the fourth case was still experiencing both sets of exacerbated prior symptoms at 12 months after their *Salmonella* infection.

Discussion

This study provides the first information on PI-IBS symptoms following *Salmonella* infection in Australia, and contributes to the limited Australian studies on ReA following *Salmonella* infection.[20-21] In our study, 18% of participants developed symptoms consistent with PI-IBS and 11% developed symptoms consistent with ReA following *Salmonella* infection.

For both conditions these findings fall within the range of results from previous studies, though for PI-IBS in particular our results sit toward the higher end of this range.[4,9,13-21,29-39] The symptoms reported by our ReA and PI-IBS cases are also consistent with those described in the published literature. For ReA, the majority of our cases experienced asymmetric monoarthritis or oligoarthritis, predominantly in the fingers and lower limbs, with heel pain and ocular symptoms also reported by more than one case.[12,17,19-

[21,23] For PI-IBS, most of our cases experienced diarrhoea-predominant PI-IBS or mixed PI-IBS (diarrhoea and constipation).[5,8,29-30,37]

Our study did find a longer duration of sequelae symptoms than previous studies, particularly for ReA, with 56% of ReA cases still experiencing symptoms at 12 months post infection. International studies conducted previously have reported 40% or less ReA cases with symptoms still at six months,[15-17,19] and summary literature suggests that most cases should recover in under a year.[23] However, symptom duration was also found to be longer in the two previously published Australian studies. Lee et al.[20] found that 55% of their ReA cases still had symptoms at 6 months, a duration which if passed has been found to be an indication of the development of chronic ReA.[12,20] Duration was not specifically reported by McColl et al.,[21] but the data presented in their study suggest that 62% of 13 ReA cases identified were still experiencing symptoms more than four months after their *Salmonella* infection. It is important that further studies are conducted in the Australian population to determine whether Australian ReA cases have a consistently longer duration of symptoms than cases in other countries, as this will have a significant impact on estimates of the burden of *Salmonella* in Australia.

We found no particular features in common in participants who still had symptoms of ReA at 12 months post infection. Unlike Thompson et al.,[38] who found that those with a higher number of joints affected at ReA onset, and those who also developed ocular symptoms tended to chronicity of symptoms at five years, those with ongoing ReA symptoms at 12 months in our study did not tend to have more sites of pain, nor did they display more ocular or other extraarticular symptoms.

Just under half of the PI-IBS case in our study still had symptoms at 12 months post infection. As stated previously, for the purposes of our study we did not re-assess adherence to the PI-IBS case definition across the period of our study; if a participant met the case definition for PI-IBS at 3 months post infection, they remained a case until they reported cessation of all associated symptoms. This makes the duration of PI-IBS found in our study difficult to compare with other studies that have followed groups over time, as they have often collected information on how many cases met the case definition at different time points,[29-30] or are unclear about how long after infection the study had been commenced.[40-41] However, the percentage of study participants who

met the Rome criteria for IBS at six months post-infection in our study was the same as the 7% reported by Neal et al..[33]

We did observe that the median age for those who were still experiencing PI-IBS symptoms at 12 months was 43, which is lower than the median age of 63 for those who met the case definition for PI-IBS overall. This would correspond with young age being identified as a risk factor for the development of PI-IBS in other studies[9,33,40,42] and may indicate that younger people are more likely to experience a longer duration of PI-IBS symptoms. However, it is important to note that these findings relate to a very small number of people (7 cases), and that those who were youngest in this group (11 and 12 years) reported that their symptoms were less severe and less frequent at 12 months, while the other five PI-IBS cases (aged 41-77) reported no change in symptom severity or frequency at 12 months. As higher age has also been suggested to be associated with persistence of symptoms,[30] larger analytical studies are required to clarify these findings.

The only statistically significant association observed in our study between exposure variables of interest and the study outcomes was between seeing an outpatient specialist clinician for the initial *Salmonella* infection/illness and the development of PI-IBS symptoms. As there is no discernible reason why seeing a specialist would cause PI-IBS symptoms, we initially thought this association likely represented the severity of the initial illness in these cases. Severity of the antecedent infection, usually indicated by the duration of diarrhoea, has been found by numerous studies to be associated with the development of PI-IBS.[5,8,22,33,37,43] However, on closer inspection of the three PI-IBS cases who saw an outpatient specialist, we found that one case had an asymptomatic *Salmonella* infection, and another reported only having symptoms for 4 days. This casts some doubt on the idea that this finding is related to the severity of the initial infection, although all of these cases obviously suffered some disruption to their normal bodily function as all reported taking antibiotics to treat their infection and needed to see a specialist.

It is also possible that there was some confusion as to what constitutes an outpatient specialist, indicated by the fact that one case who reported seeing a specialist didn't also report either seeing a GP or going to hospital. As a referral to a specialist is usually required from one of these sources, this case could have been confused as to what an

outpatient specialist is, and this question should be carefully worded in future studies. This association could also just have been detected in the data by chance.

It is interesting to note that of the six participants in our study known to have asymptomatic *Salmonella* infections, one met our case definition for ReA and also experienced exacerbated prior gastrointestinal symptoms, and one met our case definition for PI-IBS and also experienced exacerbated prior joint symptoms, indicating a severe immune reaction to the infection despite experiencing no gastrointestinal symptoms. Development of ReA symptoms in asymptomatic *Salmonella* cases was also documented by Locht et al.[17] who found mild to severe ReA symptoms in 4 cases who had asymptomatic *Salmonella* infections. However, all four of their asymptomatic cases reported that their joint symptoms resolved within a month, whereas our ReA case following asymptomatic salmonellosis still had symptoms, though less severe, at 12 months post infection, and our PI-IBS case following asymptomatic salmonellosis had gastrointestinal symptoms for 3-4 months. This finding highlights the importance of clinician awareness of post-infectious sequelae as a possible diagnosis if patients present with sudden onset arthritic and/or altered gastrointestinal symptoms in the absence of symptomatic AGE.

The only other association that came close to significance in our study was the association between taking antibiotics for the initial *Salmonella* infection and developing symptoms of ReA. Whether taking antibiotics for the initial infection has a role in the development of ReA is unclear, as taking antibiotics has been found to be both positively and negatively associated with the development of ReA in previous studies.[13,15-16,18,39] The mechanisms by which taking antibiotics may be associated with the development of ReA are also unclear. As in our study, Dworkin et al.[18] found a small positive association between antibiotic use and ReA, and suggested a number of possible mechanisms for the association, including the effect of bacterial fragments altered by antibiotics, prolonged carriage due to antibiotic use resulting in increased immune stimulation, and taking antibiotics being a proxy for more severe illness. Further studies are required to confirm and characterise this association.

Limitations

It is important to recognise that the findings presented above could be influenced by the limitations of our study. Firstly, as a result of our study design, there is a possibility that our findings could be inflated by the results of selection bias. In studies where eligible subjects self-select to participate, it is commonly recognised that those who participate might be more likely to have experienced the symptoms/outcome of interest than those who do not.[14,20,34] This is of concern in our study as our response rate was only 47%, and our participants were statistically significantly more likely to be female, which could be particularly inflating our PI-IBS finding as this condition is known to be more prevalent in females.[5,8]

Selection bias may also have been introduced through our decision to study subjects from a population of laboratory-confirmed *Salmonella* cases from a large outbreak. If those with more severe illness were disproportionally more likely to have accessed health-care and submitted a stool specimen for laboratory testing, then incidence for both ReA and PI-IBS could be inflated, as severity and duration of initial illness has been found to be associated with the development of both ReA and PI-IBS.[5,8-9,17,44]

As such, our findings could represent what has been referred to by Lee et al.[20] as a 'maximum frequency estimate' for PI-IBS and ReA following *Salmonella* infection in Australia. If we assume that all those who did not respond to the questionnaire did not develop any symptoms of PI-IBS or ReA, and we include them in our incidence calculations (excluding 10% and 30% respectively for the PI-IBS and ReA calculations as these represent the prevalence of prior IBS and arthritis in the population[6]), our PI-IBS incidence would be 9% and our ReA incidence would be 7%. These estimates are still within the ranges found by previous studies, and may represent a more conservative 'minimum frequency estimate'. However, the extent of the effect of this selection bias cannot be known. Through the follow-up of non-responders to the first questionnaire we became aware of at least two subjects who were experiencing symptoms of interest, but who decided not to participate in the study, indicating that these 'minimum frequency estimates' would likely be an underestimate of sequelae in this population.

The case definitions used in our study may also have influenced our incidence estimates. For ReA, our case definition required new joint pain, but did not explore the nature of

this pain further or employ a rheumatologist to physically examine cases. This has likely resulted in a less specific case definition that may have resulted in the inclusion of cases who would not be clinically diagnosed as having ReA. Further, for the sake of comparability with the previously published Australian studies, we chose a three month period of symptom onset while many other studies restricted this period to six weeks or less.[15,17-19] Lee et al.[20] calculated a 5% reduction in their incidence if they restricted their onset period to four weeks instead of three months. Our study did not ask when symptoms began within the three month period, so we are not able to quantify the effects of using a different time period. We would recommend that future studies request an ReA symptom onset date to make findings more broadly comparable with the published literature.

For PI-IBS, the influence of the case definition on our study findings lies predominantly with the differences in the iterations of the Rome criteria (I-IV), of which some versions are more specific than others. The Rome IV criteria used in our study is the most recent iteration, released in May 2016. In regards to the diagnosis of PI-IBS, the most significant changes in this iteration compared to the Rome III criteria are the removal of the term abdominal 'discomfort', which restricts the criteria to abdominal pain only, and an increase in the frequency with which abdominal pain is required to be experienced. Studies comparing diagnosis of IBS with the Rome III versus the Rome IV criteria have found that IBS prevalence decreases by half when employing Rome IV, with the removal of the 'discomfort' option suspected to be the predominant reason for this decrease.[45-46] As such, had our study employed the Rome III criteria instead of the newly released Rome IV, our PI-IBS incidence would have increased to 36% (compared to 18%). However, using a more restrictive case definition might have helped to avoid the inflation potentially caused by relying on self-reporting of symptoms instead of a clinical diagnosis.

It is also possible that our incidence estimates for both PI-IBS and ReA have been increased (or even decreased) by the unmeasured effects of other medical conditions and/or treatments. Although we collected information on prior diagnoses of arthritis, IBS, and IBD, many other conditions and medications are known to effect gastrointestinal and joint health, and may have caused the symptoms we have attributed to PI-IBS or ReA, or minimised them enough not to meet our case definitions.

This limitation would have been addressed in part by the inclusion of a control group in our study to determine to what extent a *Salmonella* infection may cause PI-IBS and ReA symptoms in the population. A control group would also have allowed us to determine to what extent a *Salmonella* infection may exacerbate prior gastrointestinal or rheumatological symptoms as compared to the natural progression of disease in the population. Where possible, the inclusion of a control group in studies such as these is recommended.

Our study has also suffered from the same lack of statistical power to detect associations due to small numbers as has been reported by other studies.[29,39] Excluding those with prior symptoms and those with new symptoms that didn't meet the case definition limited the number of participants that could be included in our analyses, and we were particularly underpowered to assess the association between diarrhoea duration and the outcomes of interest as these data were missing for so many cases. We acknowledge that we ideally would have included a question about duration of symptoms of the initial infection in our first questionnaire, but we suspected at the time of questionnaire development that this information would be subject to substantial recall error. However, the extent of this recall error could have been assessed by comparison to the symptom durations that were collected at the time of the outbreak, so we would recommend inclusion of this question in future studies even if symptom duration is known, if just for a measure of participant recall error at six months after infection.

Despite these limitations, we believe our findings are valid as the questions developed relating to PI-IBS were informed directly by the Rome IV diagnostic questionnaire, and the questions regarding joint symptoms were similar to those included in a validated questionnaire in another study.[14,38] Additionally, we excluded any participants who reported prior joint or abdominal pain (and other gastrointestinal symptoms) and/or had been diagnosed arthritis, IBS, or IBD, prior to their *Salmonella* infection from our case definitions for PI-IBS and ReA, so we believe we have captured only new cases of these conditions.

The major strength of our study is that it provides the first information on the incidence of PI-IBS after *Salmonella* infection in an Australian population, and also contributes to the limited information on the incidence of ReA after *Salmonella* infection in Australia. Our study provides valuable information to help inform local estimates of the burden of

Salmonella in the community, and we hope it will help to raise awareness of these conditions in the general public and in primary health care physicians to enhance post-infection diagnosis and care of *Salmonella* sequelae.

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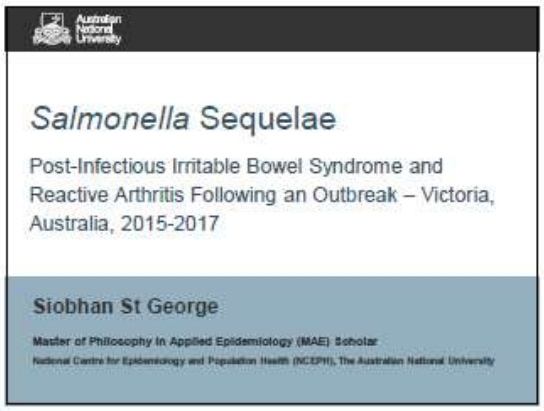
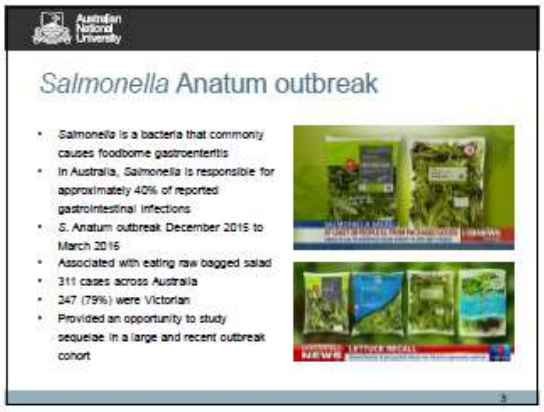
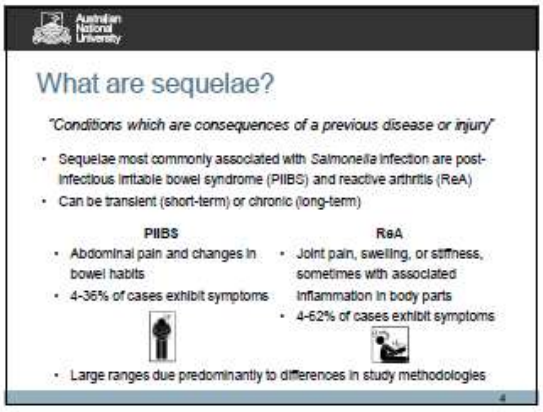
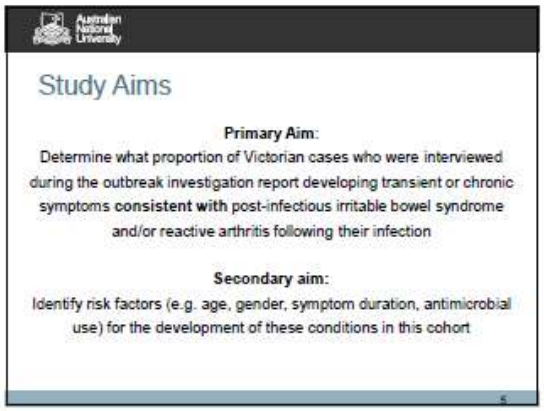
Appendices

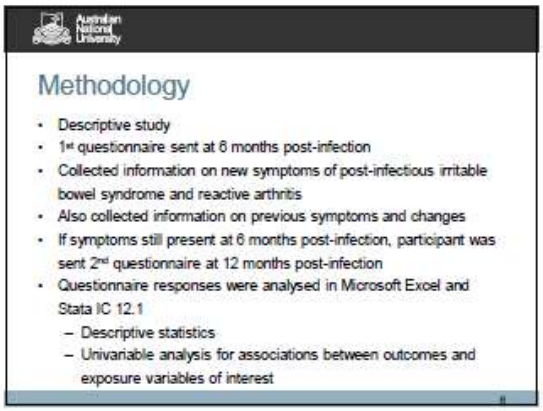
Appendix 1: TEPHINET 9th Global Scientific Conference 2017 oral presentation slides











Case definitions

Reactive Arthritis

Onset within three months of infection of new pain, swelling, or reduced movement in at least one joint

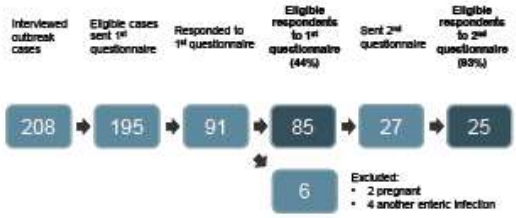
Post-infectious Irritable Bowel Syndrome

Symptoms are present for at least 3 months, and meet the Rome IV criteria:

- Recurrent abdominal pain (at least weekly)
- Pain is associated with two or more of the following criteria:
  - Related to defecation
  - Associated with a change in frequency of stool
  - Associated with a change in form (appearance) of stool

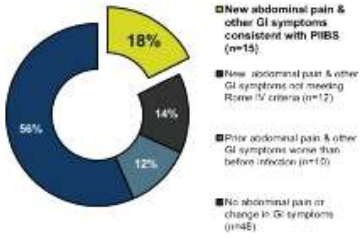
7

Participant flowchart



8

Main findings: Post-infectious irritable bowel syndrome



9

Main findings: Post-infectious irritable bowel syndrome

Duration of PIIBS symptoms

Duration of symptoms	Participants (%)
3-4 months	4 (27)
5-6 months	3 (20)*
7-8 months	-
9-10 months	1 (7)
11-12 months	-
>12 months	7 (47)

*Second questionnaire not returned by one case. Six months last known duration.

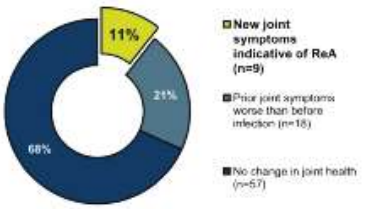
Exposure variables of interest

Exposure variable	Univariable p-value*
Age	0.742
Sex	0.754
Symptom duration	0.398
No medical care	0.302
GP care	0.407
Outpatient specialist care	0.023
Emergency visit	1.000
Hospital Admission	0.629
Took antibiotics	0.729

*χ^2 test for binary variables, Wilcoxon Rank Sum test for continuous variable (Age)

10

Main findings: Reactive Arthritis



11

Main findings: Reactive Arthritis (n=9)

Duration of ReA symptoms

Duration of symptoms	Participants (%)
Under one month	2 (22)
1-2 months	-
3-4 months	-
5-6 months	1 (11)*
7-8 months	-
9-10 months	1 (11)
11-12 months	-
>12 months	5 (56)

*Second questionnaire not returned by one case. Six months last known duration.

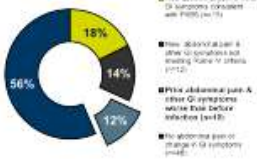
Exposure variables of interest

Exposure variable	Univariable p-value*
Age	0.618
Sex	0.092
Symptom duration	1.000
No medical care	0.576
GP care	0.330
Outpatient specialist care	1.000
Emergency visit	0.130
Hospital Admission	1.000
Took antibiotics	0.057

*χ^2 test for binary variables, Wilcoxon Rank Sum test for continuous variable (Age)

12

Main findings: Worsened previous gastrointestinal symptoms



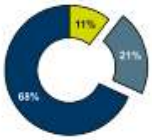
Duration of worsened GI symptoms	Participants (%) n = 10
< one month	1 (10)
1-2 months	3 (30)
3-4 months	-
5-6 months	5 (50)*†
7-8 months	-
9-10 months	-
11-12 months	-
>12 months	1 (10)

* 2nd questionnaire not consented to by one case. 8 months last known duration.

† 2 cases replied in 2nd questionnaire that they did not know whether their symptoms were still worse, so 8 months last known duration.

13

Main findings: Worsened previous joint symptoms



Duration of worsened joint symptoms	Participants (%) n = 18
< one month	1 (6)
1-2 months	2 (11)
3-4 months	2 (11)
5-6 months	3 (17)*
7-8 months	-
9-10 months	1 (6)
11-12 months	-
>12 months	9 (50)

* One case replied in 2nd questionnaire that they did not know whether their symptoms were still worse, so 6 months last known duration.

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Limitations and strengths

Limitations

- No comparison group for background rates of disease and prior disease progression
- Small sample size in univariable analysis
- Selection bias
  - May be over-representing those with sequelae symptoms
  - Significant differences in sex and age between participants and non-responders

Strengths

- First information on PIBS symptoms following an *Salmonella* outbreak in Australia
- Contributes to limited studies on Reactive Arthritis in Australia
- Also collected information on those with prior symptoms (often excluded from similar studies)
- Questions based on pre-existing or official diagnostic questionnaires, enhancing response validity

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Conclusions and public health impact

Conclusions

- 18% of participants experienced symptoms indicative of PIBS, and 11% experienced symptoms indicative of ReA
- 47% - 56% with PIBS and/or ReA were still experiencing these symptoms at 12 months post-infection
- These findings are comparable to other similar studies
- Further (larger) studies required to expand on findings of univariable analysis

Public Health Impact

- Providing the first information on PIBS incidence following *Salmonella* infection in Australia, this study will help to inform more accurate estimates of the burden of *Salmonella* infection in Australia
- Will help to raise awareness in the general public and in primary health care physicians of potential ongoing effects of *Salmonella* infection
- This awareness will enhance post-infection diagnosis and care

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- Dr Katherine Gibney
- Dr Katrina Roper (supervisor)

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Study participants
- For their time and interest

DHHS Information Officers
- For their help in receiving and sorting returned study questionnaires

All those who contributed to the initial outbreak investigation on which this study was based

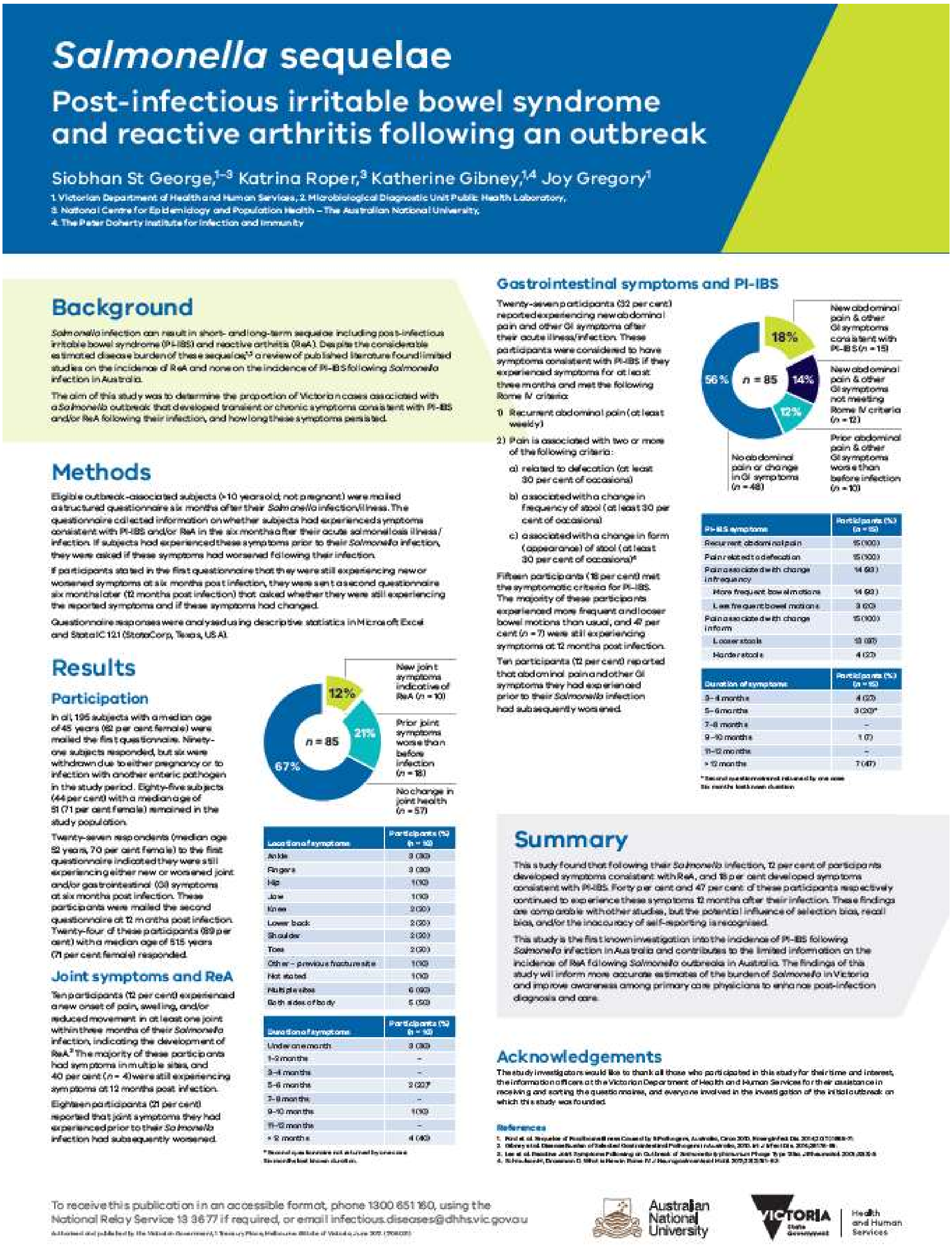
17

Thank you for listening

Questions?

18

Appendix 2: CDCC 2017 poster presentation



Salmonella sequelae

Post-infectious irritable bowel syndrome and reactive arthritis following an outbreak

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1. Victorian Department of Health and Human Services, 2. Microbiological Diagnostic Unit Public Health Laboratory, 3. National Centre for Epidemiology and Population Health – The Australian National University, 4. The Peter Doherty Institute for Infection and Immunity

Background

Salmonella infection can result in short- and long-term sequelae including post-infectious irritable bowel syndrome (PI-IBS) and reactive arthritis (ReA). Despite the considerable estimated disease burden of these sequelae,[1,2] a review of published literature found limited studies on the incidence of ReA and none on the incidence of PI-IBS following *Salmonella* infection in Australia.

The aim of this study was to determine the proportion of Victorian cases associated with a *Salmonella* outbreak that developed transient or chronic symptoms consistent with PI-IBS and/or ReA following their infection, and how long these symptoms persisted.

Methods

Eligible outbreak-associated subjects (>10 years old; not pregnant) were mailed a structured questionnaire six months after their *Salmonella* infection/illness. The questionnaire collected information on whether subjects had experienced symptoms consistent with PI-IBS and/or ReA in the six months after their acute salmonellosis illness/infection. If subjects had experienced these symptoms prior to their *Salmonella* infection, they were asked if these symptoms had worsened following their infection.

If participants stated in the first questionnaire that they were still experiencing new or worsened symptoms at six months post infection, they were sent a second questionnaire six months later (12 months post infection) that asked whether they were still experiencing the reported symptoms and if these symptoms had changed.

Questionnaire responses were analysed using descriptive statistics in Microsoft Excel and Stata IC 12.1 (StataCorp, Texas, USA).

Results

Participation

In all, 195 subjects with a median age of 45 years (62 per cent female) were mailed the first questionnaire. Ninety-one subjects responded, but six were withdrawn due to either pregnancy or to infection with another enteric pathogen in the study period. Eighty-five subjects (44 per cent) with a median age of 51 (71 per cent female) remained in the study population.

Twenty-seven respondents (median age 52 years, 70 per cent female) to the first questionnaire indicated they were still experiencing either new or worsened joint and/or gastrointestinal (GI) symptoms at six months post infection. These participants were mailed the second questionnaire at 12 months post infection. Twenty-four of these participants (89 per cent) with a median age of 51.5 years (71 per cent female) responded.

12%
21%
67%
$n = 85$
New joint symptoms indicative of ReA ($n = 10$)
Prior joint symptoms worse than before infection ($n = 18$)
No change in joint health ($n = 57$)

Location of symptoms	Participants (%) (n = 10)
Ankle	3 (30)
Fingers	3 (30)
Hip	1 (10)
Jaw	1 (10)
Knee	2 (20)
Lower back	2 (20)
Shoulder	2 (20)
Toes	2 (20)
Other – previous fracture site	1 (10)
Not stated	1 (10)
Multiple sites	6 (60)
Both sides of body	5 (50)

Duration of symptoms	Participants (%) (n = 10)
Under one month	3 (30)
1–2 months	–
3–4 months	–
5–6 months	2 (20)*
7–8 months	–
9–10 months	1 (10)
11–12 months	–
> 12 months	4 (40)

* Second questionnaire not returned by one case. Six months last known duration.

Joint symptoms and ReA

Ten participants (12 per cent) experienced a new onset of pain, swelling, and/or reduced movement in at least one joint within three months of their *Salmonella* infection, indicating the development of ReA.[3] The majority of these participants had symptoms in multiple sites, and 40 per cent ($n = 4$) were still experiencing symptoms at 12 months post infection.

Eighteen participants (21 per cent) reported that joint symptoms they had experienced prior to their *Salmonella* infection had subsequently worsened.

Gastrointestinal symptoms and PI-IBS

Twenty-seven participants (32 per cent) reported experiencing new abdominal pain and other GI symptoms after their acute illness/infection. These participants were considered to have symptoms consistent with PI-IBS if they experienced symptoms for at least three months and met the following Rome IV criteria:

1) Recurrent abdominal pain (at least weekly)
2) Pain is associated with two or more of the following criteria:
   a) related to defecation (at least 30 per cent of occasions)
   b) associated with a change in frequency of stool (at least 30 per cent of occasions)
   c) associated with a change in form (appearance) of stool (at least 30 per cent of occasions)[4]

Fifteen participants (18 per cent) met the symptomatic criteria for PI-IBS. The majority of these participants experienced more frequent and looser bowel motions than usual, and 47 per cent ($n = 7$) were still experiencing symptoms at 12 months post infection.

Ten participants (12 per cent) reported that abdominal pain and other GI symptoms they had experienced prior to their *Salmonella* infection had subsequently worsened.

18%
14%
12%
56%
$n = 85$
New abdominal pain & other GI symptoms consistent with PI-IBS ($n = 15$)
New abdominal pain & other GI symptoms not meeting Rome IV criteria ($n = 12$)
Prior abdominal pain & other GI symptoms worse than before infection ($n = 10$)
No abdominal pain or change in GI symptoms ($n = 48$)

PI-IBS symptoms	Participants (%) (n = 15)
Recurrent abdominal pain	15 (100)
Pain related to defecation	15 (100)
Pain associated with change in frequency	14 (93)
More frequent bowel motions	14 (93)
Less frequent bowel motions	3 (20)
Pain associated with change in form	15 (100)
Looser stools	13 (87)
Harder stools	4 (27)

Duration of symptoms	Participants (%) (n = 15)
3–4 months	4 (27)
5–6 months	3 (20)*
7–8 months	–
9–10 months	1 (7)
11–12 months	–
> 12 months	7 (47)

* Second questionnaire not returned by one case. Six months last known duration.

Summary

This study found that following their *Salmonella* infection, 12 per cent of participants developed symptoms consistent with ReA, and 18 per cent developed symptoms consistent with PI-IBS. Forty per cent and 47 per cent of these participants respectively continued to experience these symptoms 12 months after their infection. These findings are comparable with other studies, but the potential influence of selection bias, recall bias, and/or the inaccuracy of self-reporting is recognised.

This study is the first known investigation into the incidence of PI-IBS following *Salmonella* infection in Australia and contributes to the limited information on the incidence of ReA following *Salmonella* outbreaks in Australia. The findings of this study will inform more accurate estimates of the burden of *Salmonella* in Victoria and improve awareness among primary care physicians to enhance post-infection diagnosis and care.

Acknowledgements

The study investigators would like to thank all those who participated in this study for their time and interest, the information officers at the Victorian Department of Health and Human Services for their assistance in receiving and sorting the questionnaires, and everyone involved in the investigation of the initial outbreak on which this study was founded.

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Appendix 3: Summary report of study results for participants

Irritable bowel syndrome and reactive arthritis following an outbreak of *Salmonella* Anatum

Summary of Results: Report for Participants

This is a summary of results for study participants. For more information, please contact the study investigators at the contact details provided below:

Principal investigator: Joy Gregory

Senior Epidemiologist, OzFoodNet

Victorian Department of Health and Human Services, Communicable Disease Epidemiology and Surveillance

Phone: 1300 651 160

Email: Infectious.diseases@dhhs.vic.gov.au

Co-investigator: Siobhan Tier

Epidemiology Registrar, OzFoodNet

Victorian Department of Health and Human Services, Communicable Disease Epidemiology and Surveillance

Master of Philosophy – Applied Epidemiology (MAE) scholar, Australian National University

Phone: 1300 651 160

Email: Infectious.diseases@dhhs.vic.gov.au

Australian National University

VICTORIA State Government | Health and Human Services

Introduction

This summary report has been created for people who participated in the study "Irritable bowel syndrome and reactive arthritis following an outbreak of *Salmonella* Anatum". This study would not have been possible without your participation, and we thank you again for your valuable contribution.

The main aim of this study was to find out how many people developed new symptoms of irritable bowel syndrome or reactive arthritis after their *Salmonella* infection, and how long these symptoms lasted for. We also aimed to find out whether people who had gastrointestinal symptoms or joint pain before their *Salmonella* infection thought these symptoms had become worse after their infection.

There are currently no published studies on how many people experience symptoms of irritable bowel syndrome after *Salmonella* infection in Australia. There are only two studies that look at how many people experience reactive arthritis after *Salmonella* infection in Australia[1,2]. This study has helped to increase the amount of information we have about irritable bowel syndrome and reactive arthritis after *Salmonella* infection in Australia.

Participants

We invited 195 people who had been reported to have a *Salmonella* Anatum infection and who completed an outbreak investigation interview between December 2015 and March 2016 to participate in this study. Of the 195 people invited to participate, we received completed questionnaires from 91 people (47 per cent), of whom 85 people were eligible to participate. Those who participated in this study were mostly female (71 per cent) and ranged in age between 11 and 85 years old. The average (mean) age of the group was 51 years.

Main findings

Symptoms of irritable bowel syndrome

Our study found that 15 participants (18 per cent) developed new symptoms of irritable bowel syndrome following their *Salmonella* infection. This is similar to other studies from overseas, which found that between four and 36 per cent of people develop symptoms of irritable bowel syndrome after a *Salmonella* infection[3].

Seven of the 15 participants (47 per cent) that developed new symptoms of irritable bowel syndrome reported that they still had these symptoms 12 months after their *Salmonella* infection. One participant reported that their symptoms lasted for nine-ten months, and six participants reported that their symptoms lasted for less than six months. The full length of symptoms was unknown for one person who did not complete the second questionnaire. This participant had reported still having symptoms of irritable bowel syndrome six months after their infection in the first study questionnaire.

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Symptoms of reactive arthritis

Our study found that nine participants (11 per cent) developed new joint pain and other symptoms of reactive arthritis following their *Salmonella* infection. This result lies between the results of the two previous Australian studies, which found that five and 15 per cent of people developed symptoms of reactive arthritis after a *Salmonella* infection[1,2].

Five of the nine participants (56 per cent) that developed symptoms of reactive arthritis reported that they still had these symptoms 12 months after their *Salmonella* infection. One participant reported having symptoms for up to ten months, and two participants reported that their reactive arthritis symptoms lasted for less than one month. The full length of symptoms was again unknown for another participant who did not complete the second questionnaire, but had reported still having symptoms of reactive arthritis six months after their infection.

Effects on participants with prior gastrointestinal symptoms or joint pain

Ten participants (12 per cent) reported that gastrointestinal symptoms they had experienced before their *Salmonella* infection had worsened in the following six months. Only one of these participants was still experiencing these worsened symptoms at 12 months after their infection. The majority of these participants (60 per cent) experienced worsened gastrointestinal symptoms for less than six months.

Eighteen participants (21 per cent) reported that joint symptoms they had experienced before their *Salmonella* infection had worsened in the following six months. Nine of these 18 participants (50 per cent) were still experiencing worsened joint symptoms at 12 months after their infection. Of the other 50 per cent, most (7 out of 9) experienced worsened symptoms for less than six months.

It is important to keep in mind, however, that it is possible these prior gastrointestinal and joint symptoms got worse naturally, and not because of the *Salmonella* infection. We would recommend that future studies include a comparison group with similar gastrointestinal symptoms or joint pain who did not have a *Salmonella* infection. By comparing these two groups, these future studies would be able to tell whether having a *Salmonella* infection causes these prior symptoms to worsen more than they naturally would.

Conclusions

The main aim of this study was to find out how many people developed new symptoms of irritable bowel syndrome and/or reactive arthritis after their *Salmonella* infection, and how long these symptoms lasted for. Our study found that 18 per cent of study participants developed symptoms of irritable bowel syndrome, and 11 per cent developed symptoms of reactive arthritis. Many of these participants were still experiencing these symptoms 12 months after their infection. The results of this study will contribute to the limited information we have about these conditions in Australia. This will help to improve health planning, and will help to raise awareness of these conditions in the general public and in doctors to improve diagnosis and care of these conditions.

References

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Appendix 4: Example of adult study invitation letter for first questionnaire

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19/08/2016

Study Participant Number: 040

Dear

Earlier this year (February 2016) you were diagnosed with a *Salmonella* infection, which was notified to the Victorian Department of Health and Human Services. As you had the same type of *Salmonella* infection that was part of an outbreak investigation, you were contacted by the Department and you completed a questionnaire about the foods you consumed before you became unwell.

We are now inviting all of the people involved in this outbreak who completed a questionnaire to participate in a research project that aims to find out how many people experience ongoing or new symptoms following a *Salmonella* infection. This study is being carried out by public health specialists in the Victorian Department of Health and Human Services who hope this research will contribute to a better understanding of the true community disease burden of *Salmonella* in Victoria, and help to better prevent and manage this disease and its complications in the future. If you would like to participate, you will just need to complete the short questionnaire included with this letter, which asks some questions about your *Salmonella* infection and specific symptoms which you may have experienced before and after this infection.

Further information about this research project and details about participating are provided in the Participant Information Sheet also included with this letter. The questionnaire will take approximately 10 to 15 minutes to complete, and different options are available to complete the questionnaire depending on your preference: you can fill in the paper copy questionnaire included with this letter and return it in the reply paid envelope enclosed; or you can call a research investigator on 1300 651 160 to complete the questionnaire on the telephone.

Participation in this research is entirely voluntary. If you do not wish to participate, please return the questionnaire in the reply paid envelope enclosed without completing the questions, or contact the research investigators to withdraw. If you have any questions about this research project, please contact the researchers by email (Siobhan.Tier@dhhs.vic.gov.au) or telephone (1300 651 160).

Yours sincerely,

Siobhan Tier
Epidemiology registrar and research investigator
Victorian Department of Health and Human Services

Appendix 5: Adult participant information sheet

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Participant Information Sheet

Adult participant

Project: Irritable bowel syndrome and reactive arthritis following an outbreak of *Salmonella* Anatum.

Principal investigator: Joy Gregory

Senior Epidemiologist, OzFoodNet

Victorian Department of Health and Human Services, Communicable Disease Epidemiology and Surveillance

Phone: 1300 651 160

Email: joy.gregory@dhhs.vic.gov.au

Co-investigator: Siobhan Tier

Epidemiology Registrar, OzFoodNet

Victorian Department of Health and Human Services, Communicable Disease Epidemiology and Surveillance

Master of Philosophy – Applied Epidemiology (MAE) student, Australian National University

Phone: 1300 651 160

Email: siobhan.tier@dhhs.vic.gov.au

You are invited to take part in this research project. Please read this Participant Information Sheet in full before deciding whether or not to participate in this research. Participation in this research project is entirely voluntary. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

What is the purpose of this research?

Gastroenteritis ('gastro') can be caused by many different pathogens ('bugs'). Gastro is usually a mild illness which quickly resolves. However, sometimes gastro can trigger complications, such as irritable bowel syndrome (IBS – abdominal discomfort and changes in bowel habits) and reactive arthritis (joint pain, swelling, or stiffness, sometimes with associated inflammation in other areas of the body). These complications can last from months to years. This study aims to find out how often these complications are triggered by an illness caused by *Salmonella* by asking people interviewed after a recent *Salmonella* investigation if they have developed symptoms associated with these conditions. If IBS and reactive arthritis are commonly triggered by this bug, it will change the way we think about the importance and burden of this bug in Victoria, and the resources needed to prevent and manage this type of gastro infection and its complications. It will also help to inform medical practitioners about the risk of developing these conditions after a *Salmonella* infection, so that they may better understand potential causes of these conditions when they occur.

Why were you chosen for this research?

You were chosen to participate in this study because your doctor and/or laboratory notified the Department of Health and Human Services of your *Salmonella* infection between December 2015 and April this year. As you had the same type of *Salmonella* infection (*Salmonella* Anatum) that caused an

outbreak of illness, you then completed an outbreak investigation questionnaire with the Department of Health and Human Services. We are inviting all of the people involved in this outbreak who completed an outbreak investigation questionnaire to participate in this research. Please note that although you are being invited to participate in this research project because you previously completed an outbreak investigation questionnaire, your participation in this research project is separate from your participation in the outbreak investigation questionnaire, and is entirely voluntary.

What does participation in this research involve?

At 6 months after your *Salmonella* infection, we are inviting you to complete a questionnaire involving questions about your recent health and past medical history. If your responses to this questionnaire indicate that you have specific symptoms of interest, you will be invited to complete a similar questionnaire in another six months (12 months after your infection) to see if you still have these symptoms at this point in time.

These questionnaires will take approximately 10–15 minutes to complete, and the first questionnaire has been posted to you along with an invitation letter and this Participant Information Sheet. Depending on your preference, these questionnaires can be completed in paper form and returned via the reply-paid envelope supplied, or can be completed over the telephone. These questionnaires will not include any information that could identify you apart from a study participant number, which is required so that we can tell who has returned their questionnaire/s and who has not. Information regarding your initial *Salmonella* infection including the symptoms you experienced at the time, when you began experiencing them, and how long they lasted have been taken from the outbreak investigation questionnaire you previously completed with the Department of Health and Human Services.

There are no costs associated with participating in this research project, and you won't be paid to participate. This research project has been designed to avoid bias to ensure the researchers interpret the results in a fair and appropriate way and cannot make unfounded conclusions.

Possible benefits and risks to participants

Participation in this study does not involve any risks of harm to you. If you have concerns about your diagnosed *Salmonella* infection or any ongoing symptoms, please discuss these with your general practitioner. Additionally, you are welcome to contact Siobhan Tier (co-investigator – contact details above) to discuss any concerns you have arising from this study.

While completing this questionnaire is unlikely to benefit you directly, when many responses are combined we hope to get a good picture of possible complications following *Salmonella* infection. This will help doctors and public health specialists better understand the burden of these diseases on individuals and on society and may contribute to better prevention and treatment strategies in the future.

Consenting to participate in the research and withdrawing from the research

Participation in this study is entirely voluntary. If you return a completed questionnaire you are consenting to participate in this research project. If you return a blank questionnaire, or if you contact us to inform us that you do not wish to participate in this study, you will be withdrawn and will not be contacted regarding this research project again. You will be asked when completing the first questionnaire whether you consent to us sending the second questionnaire to you in another six months' time if relevant. You will also be asked if you consent to us contacting you if we need to clarify any of your questionnaire responses with you. If we do not receive a completed questionnaire from you two weeks after it was initially sent, we will call you to ask whether you consent to participate in the research and how you would prefer to complete the questionnaire.

It is important to note that as the questionnaires are only identifiable by a study participant number, and the link between the study participant numbers and the Department of Health and Human Services identifiers will be destroyed once all data has been collected (as detailed below) it will not be possible to withdraw your data once all of the questionnaires have been submitted. If you wish to withdraw from the study after your questionnaire has been submitted, please make sure to do so before March 2017 by contacting the research investigators.

Confidentiality

All participants will be assigned a study participant number and all data will be collected and recorded against this number. In a separate and secure file, participant study numbers will be matched with Department of Health and Human Services identifiers to allow us to know who has completed the first questionnaire and who has withdrawn from the study. This is so we know who to send the second questionnaire to and who not to contact again. Once the data collection process for both questionnaires is complete and the data is ready for analysis, we will delete the file that matches the study numbers and the Department of Health and Human Services identifiers so that all data is de-identified and anonymous for both analysis and reporting. Data will only be reported in aggregate form to protect the confidentiality and anonymity of participants.

Storage of data

Data collected will be stored in accordance with Department of Health and Human Services and Australian National University regulations. Information that allows researchers to identify participants will not be retained after the collection and preparation of data for analysis is complete. De-identified electronic data will be kept in password-protected files on a secure Department of Health and Human Services network drive. De-identified paper-based data will be kept in a locked cabinet in a secure area of the Department of Health and Human Services. Only researchers directly involved in this study will have access to this data. The de-identified data will be kept for 7 years following publication of the results of this study, after which it will then be disposed of in a secure manner.

Results

Results of the research project will be made publicly available from November 2017. Participants who would like to request a copy of the research project report are encouraged to contact the Coordinating

Principle Investigator (contact details above) or the Victorian Department of Health and Human Services on 1300 651 160 at this time. Results from this study will additionally be published in the scientific literature, and will form part of the co-investigator's (Siobhan Tier) Master of Philosophy – Applied Epidemiology thesis.

Source of funding and approval

This study is funded by the Department of Health and Human Services, Victoria. Additionally, Siobhan Tier receives funding from the Victorian Department of Health and Human Services (through the Australian Government Department of Health OzFoodNet Program) and the Microbiological Diagnostic Unit Public Health Laboratory via a postgraduate scholarship.

All research in Australia involving humans is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this research project have been approved by the HREC of both the Victorian Department of Health and Human Services and the Australian National University. This project will be carried out according to the National Statement on Ethical Conduct in Human Research (2007). This statement has been developed to protect the interests of people who agree to participate in human research studies.

Privacy notice and complaints

In collecting your personal information within this research the Department of Health and Human Services must comply with all relevant privacy legislation, including the Privacy Act 1988 (Commonwealth), the Privacy and Data Protection Act 2014 (Vic) and the Health Records Act 2001 (Vic).

If you would like to access the information collected on you within this research, please contact the research investigators (contact details above) before March 2017. You will be unable to access this information after March 2017 as the data will be made anonymous when the link between the study participant numbers and the Department of Health and Human Services identifiers is destroyed.

Should you have any concerns or complaints about the conduct of the project, please contact the Executive Officer of the Victorian Department of Health and Human Services Human Research Ethics Committee:

Executive Officer
Victorian Department of Health and Human Services Human Research Ethics Committee
50 Lonsdale Street, Melbourne, Victoria, 3000
Phone: 1300 651 160
Email: research.ethics@dhhs.vic.gov.au

Thank you,

Siobhan Tier
Epidemiology registrar and research investigator
Department of Health and Human Services, Victoria

Page 4 of 4

Appendix 6: Example of adult first study questionnaire

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Irritable bowel syndrome and reactive arthritis following an outbreak of *Salmonella* Anatum.

Questionnaire for adults

Introduction

The purpose of this research project is to find out how often changes in bowel habits and joint pain are triggered by *Salmonella* infection. This information will help us better understand the burden of this disease on individuals and on society and may contribute to better prevention and treatment strategies in the future. To do this, we are contacting people who had a *Salmonella* Anatum infection notified to the Victorian Department of Health and Human Services between December 2015 and April 2016, and who also completed an interview about their *Salmonella* infection at that time. Detailed information about this research project is provided in the Participant Information Sheet sent with this questionnaire.

This questionnaire includes questions about your *Salmonella* infection, past medical history, and health since your *Salmonella* infection. Some questions will ask about your health in particular periods of time. This will be clearly indicated on the questionnaire where relevant. If you are not sure about an answer or you cannot remember the answer to a question, just answer as best you can. This questionnaire will take approximately 10 to 15 minutes to complete and can be returned using the reply paid envelope supplied. If you have any questions about this questionnaire, or if you would prefer to complete this questionnaire over the telephone, please call research investigator Siobhan Tier on 1300 651 160.

Instructions

You are welcome to shade ● or tick ☑ the circles or squares to indicate your response, but please do not use a cross ☒ unless you have made a mistake.

○ circles indicate that only one choice is available

☐ squares indicate that multiple responses are allowed

If you make a mistake, or want to change any of your responses, please place a cross through the incorrect response ☒ and then shade or tick the correct response. For written responses, please cross out your incorrect response and write your new response just above or below the one you have crossed out. If you have any questions about completing this questionnaire, please contact the study investigators at the contact details provided on the Participant Information Sheet.

Page 1 of 11

Participant number: 040

Section 1. Your *Salmonella* infection and past medical history

Q1. Which of the following medical care did you receive for your *Salmonella* infection in February 2016? [*Select all that apply*]

- ☐ No medical care
- ☐ GP (general practitioner or family doctor) visit(s)
- ☐ Specialist doctor as an outpatient visit(s)
- ☐ Emergency department visit(s)
- ☐ Hospital admission
- ☐ Other → please specify type/s _____
- ☐ I don't know

Q2. Did you take antibiotics to treat your *Salmonella* infection?

- ○ No
- ○ Yes → please specify type/s (if known) _____
- ○ I don't know

Q3. For women: Are you currently pregnant or have you been pregnant at any time between your *Salmonella* infection and now?

- ○ No
- ○ Yes → Go to Section 6 (p. 11)
- ○ I don't know
- ○ Does not apply to me

Q4. Prior to your *Salmonella* infection, had a doctor ever diagnosed you with:

a) Irritable bowel syndrome

- ○ No
- ○ Yes
- ○ I don't know

b) Inflammatory bowel disease (e.g., Crohn's disease or ulcerative colitis)

- ○ No
- ○ Yes
- ○ I don't know

c) Arthritis

- ○ No
- ○ Yes → please specify type of arthritis (if known) _____
- ○ I don't now

Participant number: 040

Section 2. **The following questions relate to bowel symptoms**

When you were interviewed about your *Salmonella* infection, you indicated that your illness began on the 1st of February 2016 and lasted for 14 days. Unless otherwise specified, all questions relate to symptoms that began after the illness from your *Salmonella* infection got better on the 14th of February 2016.

Q5. At any time in the last 6 months (after your *Salmonella* infection), have you had pain anywhere in your abdomen?

- ○ No → go to Question 31 (p. 9)
- ○ Yes

Q6. For women: Did you only experience this abdominal pain during your menstrual bleeding (period)?

- ○ Yes → go to Question 31 (p. 9)
- ○ No - I experienced this abdominal pain at other times apart from during my period
- ○ I don't know
- ○ Does not apply to me

Q7. **a)** For all: Was this abdominal pain present before your *Salmonella* infection?

- ○ No → go to Question 8 (p. 4)
- ○ I don't know → go to Question 8 (p. 4)
- ○ Yes

b) If yes, did this abdominal pain get worse in the 3 months after your *Salmonella* infection?

- ○ No → go to Question 31 (p. 9)
- ○ I don't know → go to Question 31 (p. 9)
- ○ Yes

c) If yes, and if you also had other gastrointestinal symptoms (such as diarrhoea, loose stool, or constipation) before your *Salmonella* infection, did these other symptoms also get worse after your *Salmonella* infection?

- ○ I did not have any other gastrointestinal symptoms before my *Salmonella* infection
- ○ No
- ○ I don't know
- ○ Yes → please specify the symptoms that got worse after the *Salmonella* infection

_____

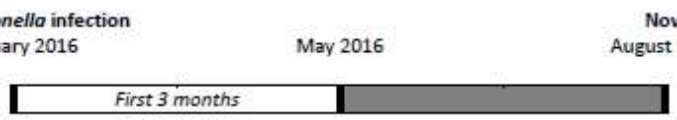
d) How long was your abdominal pain (and any additional gastrointestinal symptoms) worse for following your *Salmonella* infection?

- ○ Less than one week
- ○ One to two weeks
- ○ Three to four weeks
- ○ One to two months
- ○ Three to four months
- ○ Five to six months
- ○ Still worse
- ○ I don't know

If you have completed questions 7b - 7d (if your abdominal pain was present before your Salmonella infection), please continue to question 31 (p. 9).

Participant number: 040

Questions 8 to 17 relate to symptoms you might have experienced during the *first 3 months after* your *Salmonella* illness ended in February 2016 (between February and May 2016).



Q8. In the first 3 months after your *Salmonella* infection, how often did you have pain anywhere in your abdomen?

- ○ Never →go to Question 18 (p. 6)
- ○ Less than one day a month
- ○ One day a month
- ○ Two to three days a month
- ○ One day a week
- ○ Two to four days a week
- ○ Five to six days a week
- ○ Every day

Q9. When did this abdominal pain begin?

- ○ Straight after my *Salmonella* infection
- ○ Sometime after my *Salmonella* infection → please specify date (or closest estimate if exact date unknown) _____

Q10. How often did this abdominal pain happen just before, during, or soon after you had a bowel movement (poo)?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q11. In the first three months after your *Salmonella* infection, how often did you have more frequent bowel movements (poos) than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time

Q12. In the first three months after your *Salmonella* infection, how often did you have less frequent bowel movements (poos) than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Participant number: 040

Q13. In the first three months after your *Salmonella* infection, how often were your bowel movements (poos) softer than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q14. In the first three months after your *Salmonella* infection, how often were your bowel movements (poos) harder than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q15. In the first three months after your *Salmonella* infection, how often did you have soft, mushy, or watery bowel movements (poos) when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q16. In the first three months after your *Salmonella* infection, how often did you have hard or lumpy bowel movements (poos) when you had this abdominal pain?

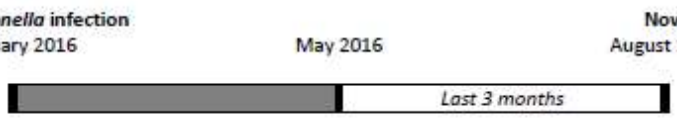
- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q17. How long did this abdominal pain and any of the other symptoms mentioned above last for? *[If different symptoms lasted for different periods of time, please select the period of the longest lasting symptom.]*

- ○ Less than one week
- ○ One to two weeks
- ○ Three to four weeks
- ○ One to two months
- ○ Three to four months
- ○ Five to six months
- ○ Still experiencing symptoms

Participant number: 040

Questions 18 to 26 relate to symptoms you might have experienced *in the last 3 months* – in the three months up to and including when you are completing this questionnaire (between May and August 2016).



Q18. In the last 3 months, how often have you had pain anywhere in your abdomen?

- ○ Never →go to Question 27 (p. 8)
- ○ Less than one day a month
- ○ One day a month
- ○ Two to three days a month
- ○ One day a week
- ○ More than one day a week
- ○ Every day

Q19. Did this abdominal pain begin in the last 3 months?

- ○ No, beforehand
- ○ Yes → please specify date (or closest estimate if exact date unknown) _____

Q20. In the last 3 months, how often has this abdominal pain happened just before, during, or soon after you had a bowel movement (poo)?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q21. In the last 3 months, how often have you have more frequent bowel movements (poos) than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q22. In the last 3 months, how often have you had less frequent bowel movements (poos) than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Participant number: 040

Q23. In the last 3 months, have your bowel movements (poos) been softer than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q24. In the last 3 months, have your bowel movements (poos) been harder than usual when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q25. In the last 3 months, how often have you had soft, mushy, or watery bowel movements (poos) when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Q26. In the last 3 months, how often have you had hard or lumpy bowel movements (poos) when you had this abdominal pain?

- ○ Never
- ○ Rarely (About 10% of the time)
- ○ Sometimes (About 30% of the time)
- ○ Often (About 50% of the time)
- ○ Most of the time (About 70% of the time)
- ○ Almost always (About 90% of the time)
- ○ Always (100% of the time)

Participant number: 040

Questions 27 to 30 relate to your medical history in the whole period of time between your *Salmonella* infection and now (August 2016).

Q27. What, if any, medical care have you received for your abdominal pain or change in bowel habit in the 6 months following your *Salmonella* infection? [*Select all that apply*]

- ☐ No medical care
- ☐ GP (general practitioner or family doctor) visit(s)
- ☐ Specialist doctor as an outpatient visit(s)
- ☐ Emergency department visit
- ☐ Hospital admission
- ☐ Other → please specify type/s _____
- ☐ I don't know

Q28. Since your *Salmonella* infection, has a doctor diagnosed you with:

a) Irritable bowel syndrome

- ○ No
- ○ Yes
- ○ I don't know

b) Inflammatory bowel disease (e.g., Crohn's disease or ulcerative colitis)

- ○ No
- ○ Yes
- ○ I don't know

Q29. Since your *Salmonella* infection have you taken any medications to relieve your abdominal pain or change in bowel habits?

- ○ No
- ○ Yes → please specify type/s (if known) _____
- ○ I don't now

Q30. Since your *Salmonella* infection has your abdominal pain, or change in bowel habits, stopped you going to work, school, or being able to undertake your usual daily activities?

- ○ No
- ○ Yes → please specify how many days you have been unable to work, go to school, or complete your usual daily activities _____(days)
- ○ I don't know

Participant number: 040

Section 3. **The following questions relate to joint symptoms**

Q31. Have you had pain, swelling and/or reduced movement in at least one joint in the 6 months since your *Salmonella* infection?

- ○ No → Go to Question 41 (p.11)
- ○ I don't know → Go to Question 41 (p.11)
- ○ Yes

Q32. **a)** Did you have these joint symptoms before your *Salmonella* infection?

- ○ No → Go to Question 33
- ○ I don't know → Go to Question 33
- ○ Yes

b) If yes, did these symptoms worsen in the 3 months after your *Salmonella* infection?

- ○ No → go to Question 41 (p.11)
- ○ I don't know → go to Question 41 (p.11)
- ○ Yes

c) If yes, how long were your symptoms worse for?

- ○ Less than one week
- ○ One to two weeks
- ○ Three to four weeks
- ○ One to two months
- ○ Three to four months
- ○ Five to six months
- ○ Still worse
- ○ I don't know

d) How did your symptoms worsen? *[Select all that apply]*

- ☐ Increased joint pain or stiffness
- ☐ Increased joint swelling
- ☐ Pain, swelling, or stiffness in previously well (unaffected) joint/s
- ☐ Other → please specify _____

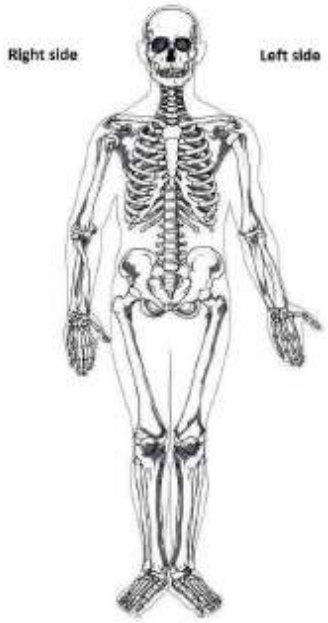
If you have completed questions 32b - 32d (if your joint symptoms were present before your Salmonella infection) please continue to Question 41 (p. 11)

Q33. Did your joint symptoms start within the first 3 months after your *Salmonella* infection (between February and May 2016)?

- ○ No, after then → go to Question 41 (p. 11)
- ○ Yes
- ○ I don't know

Participant number: 040

Q34. Which joints have been affected? *[Please circle the affected joints on the picture below]*



Q35. How long did these joint symptoms last? *[If different symptoms lasted for different periods of time, please select the period of the longest lasting symptom.]*

- ○ Less than 1 week
- ○ 1 to 2 weeks
- ○ 3 to 4 weeks
- ○ 1 to 2 months
- ○ 3 to 4 months
- ○ 5 to 6 months
- ○ Still experiencing symptoms
- ○ I don't know

Q36. What, if any, medical care have you received for your joint symptoms following your *Salmonella* infection? *[Select all that apply]*

- ☐ No medical care
- ☐ GP (general practitioner or family doctor) visit(s)
- ☐ Specialist doctor as an outpatient visit(s)
- ☐ Emergency department visit(s)
- ☐ Hospital admission
- ☐ Other → please specify type/s _____
- ☐ I don't know

Q37. Since your *Salmonella* infection, has a doctor diagnosed you with arthritis?

- ○ No
- ○ Yes → please specify type of arthritis (if known) _____
- ○ I don't now

Participant number: 040

Q38. Since your *Salmonella* infection have you taken any medications to relieve your joint symptoms?

- ○ No
- ○ Yes → please specify type (if known) _____
- ○ I don't now

Q39. Since your *Salmonella* infection have your joint symptoms stopped you going to work, school, or being able to undertake your usual daily activities?

- ○ No
- ○ Yes → please specify how many days you have been unable to work, go to school, or complete your usual daily activities _____(days)
- ○ I don't know

Section 4. Other symptoms

Q40. Some people also develop other symptoms related to their joint pain. In the 3 months after your *Salmonella* infection, did you have any of the following symptoms? *[Select all that apply]*

- ☐ Heel pain
- ☐ Red, itchy, or burning eyes
- ☐ Painful mouth ulcers
- ☐ Rash on palms of hands or soles of feet
- ☐ Rash on genitals
- ☐ Discharge from genitals or burning on urination
- ☐ None of the above

Section 5. Future contact

Q41. Do you consent to being contacted by a researcher to clarify any of the responses you have given to this questionnaire if required?

- ○ Yes
- ○ No

Q42. Do you consent to being sent a second similar (shorter) questionnaire in another 6 months' time if you are eligible?

- ○ Yes
- ○ No

Section 6. Please return your questionnaire in the reply-paid envelope provided or via email to: Siobhan.Tier@dhhs.vic.gov.au

---------- Thank you! Your participation in this research is greatly appreciated. ----------

Appendix 7: Example of adult second study questionnaire

Australian National University

VICTORIA State Government | Health and Human Services

Irritable bowel syndrome and reactive arthritis following an outbreak of *Salmonella* Anatum.

Questionnaire 2 for adults

Introduction

The purpose of this research project is to find out how often changes in bowel habits and joint pain are triggered by *Salmonella* infection. To do this we are following up people who had a *Salmonella* Anatum infection notified to the Victorian Department of Health and Human Services between December 2015 and March 2016. This information will help us better understand the burden of this disease on individuals and on society and may contribute to better prevention and treatment strategies in the future. Detailed information about the research project is provided in the Participant Information Sheet sent with this questionnaire.

You have been sent this second follow-up questionnaire as your responses to the first questionnaire you completed last year indicated you had ongoing symptoms associated with your *Salmonella* infection. This questionnaire includes questions about your current and recent health. If you are not sure about an answer or you cannot remember the answer to a question, just answer as best you can. This questionnaire will take approximately 5 to 10 minutes to complete and can be returned using the reply paid envelope supplied.

Instructions

You are welcome to shade or tick the circles or squares to indicate your response, but please do not use a cross unless you have made a mistake.

- ○ circles are provided where only one choice is permitted.
- ☐ squares indicate that multiple responses are permitted.

If you make a mistake, or want to change any of your responses, please place a cross through the incorrect response and then shade or tick the correct response. For written responses, please cross out your incorrect response and write your new response just above or below the one you have crossed out. If you have any questions about completing this questionnaire, please contact the study investigators at the contact details provided on the Participant Information Sheet.

Page 1 of 6

Participant number: 040

When you completed the first questionnaire for this research project in 2016, your responses indicated that you were experiencing ongoing symptoms associated with your *Salmonella* infection. This questionnaire aims to determine whether these symptoms have changed and whether these symptoms are still continuing, and if not, how long they lasted for after you completed the first questionnaire. Unless otherwise stated, all questions relate to symptoms you may or may not have experienced in the last 6 months (from September 2016 to February 2017).

Section 1. Your current health

Q1. For women: Are you currently pregnant or have you been pregnant at any time between when you completed the first questionnaire and now?

- ○ No
- ○ Yes → *Go to Section 5*
- ○ I don't know
- ○ Does not apply to me

Q2. Since you completed the first questionnaire in 2016, has a doctor diagnosed you with:

a) Irritable bowel syndrome

- ○ No
- ○ Yes
- ○ I don't know

b) Inflammatory bowel disease (e.g., Crohn's disease or ulcerative colitis)

- ○ No
- ○ Yes
- ○ I don't know

c) Arthritis

- ○ No
- ○ Yes → specify type of arthritis (if known) _____
- ○ I don't now

Participant number: 040

Section 2. Bowel symptoms

In the questionnaire you completed last year, you stated that you were experiencing the following bowel symptoms at that time:

- Abdominal pain
- Abdominal pain that occurred just before, during, or soon after a bowel movement (poo)
- More frequent bowel movements than usual
- Softer than usual bowel movements
- Soft, mushy, or watery bowel movements
- Hard or lumpy bowel movements

Q3. a) Are you still experiencing some or all of these symptoms?

- ○ No → go to Question 4
- ○ I don't know → go to Question 5
- ○ Yes

b) If yes, which symptoms are you still experiencing? *[Please select all that apply]*

- ☐ Abdominal pain
- ☐ Abdominal pain that occurs just before, during, or soon after a bowel movement
- ☐ More frequent bowel movements than usual
- ☐ Softer than usual bowel movements
- ☐ Soft, mushy, or watery bowel movements
- ☐ Hard or lumpy bowel movements

c) Over the past 6 months, have these symptoms changed?

- ○ No → go to Question 5
- ○ I don't know → go to Question 5
- ○ Yes

d) If yes, how have these symptoms changed? *[Please select all that apply]*

- ☐ Symptoms are more severe
- ☐ Symptoms are more frequent
- ☐ Symptoms are less severe
- ☐ Symptoms are less frequent
- ☐ Other → please specify _____

Please proceed to Question 5

Participant number: 040

Q4. When did your symptoms stop? *[If you can't remember the exact date, please enter an approximate date. If symptoms stopped at different times, please list the date on which the last symptom stopped]*

_____

_____

Q5. What, if any, medical care have you received for your bowel symptoms in the last 6 months? *[Select all that apply]*

- ☐ No medical care
- ☐ GP (general practitioner or family doctor) visit(s)
- ☐ Specialist doctor as an outpatient visit(s)
- ☐ Emergency department visit
- ☐ Hospital admission
- ☐ Other → please specify _____

Q6. In the last 6 months have you taken any medications to relieve your bowel symptoms?

- ○ No
- ○ Yes → specify type/s (if known) _____
- ○ I don't now

Q7. In the last six months have your bowel symptoms stopped you going to work, school, or being able to undertake your usual daily activities?

- ○ No
- ○ Yes → specify how many days you have been unable to work, go to school, or complete your usual daily activities _____
- ○ I don't know

Participant number: 040

Section 3. Joint symptoms

In the questionnaire you completed last year you indicated that at that time, joint symptoms you had experienced prior to your *Salmonella* infection had worsened in the following ways:

- Increased joint pain or stiffness
- Increased joint swelling

Q8. **a)** Are you still experiencing any of these worsened symptoms (in comparison to the joint symptoms you experienced before your *Salmonella* infection)?

- ○ No → go to Question 9
- ○ I don't know → go to Question 10
- ○ Yes

b) If yes, which worsened symptoms are you still experiencing? *[Please select all that apply]*

- ☐ Increased joint pain or stiffness
- ☐ Increased joint swelling

c) Over the past 6 months, have these symptoms changed?

- ○ No → go to Question 10
- ○ I don't know → go to Question 10
- ○ Yes

d) If yes, how have these symptoms changed? *[Please select all that apply]*

- ☐ Symptoms are more severe
- ☐ Symptoms are less severe
- ☐ Symptoms are affecting more previously well joints
- ☐ Other → please specify _____

Please proceed to Question 10

Q9. When did your worsened joint symptoms return to the same level as prior to your *Salmonella* infection? *[If you can't remember the exact date, please enter an approximate date. If symptoms stopped at different times, please list the date on which the last symptom stopped]*

_____

Participant number: 040

Section 4. **Future contact**

Q10. Do you consent to being contacted by a research investigator to clarify any of the responses you have given to this questionnaire if required?

- ○ Yes
- ○ No

Section 5. Please return your questionnaire in the reply-paid envelope provided or via email to: Siobhan.Tier@dhhs.vic.gov.au

---Thank you! Your participation in this research is greatly appreciated and is now complete. ---

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Chapter IV:

Analysis of a Public Health Dataset

Analysis of the Victorian Food Frequency Survey (VFFS), 2014-2016

Table of Contents

Preface

Background to project

This project was proposed by Joy Gregory and Zoe Cutcher of OzFoodNet Victoria. The Victorian Food Frequency Survey (VFFS) was conducted to provide data on the frequency with which well Victorians consumed certain food items, with the aim of comparing this data to information collected from *Salmonella* case interviews (and to a lesser extent interviews for cases of other enteric pathogens such as *Campylobacter* and Shiga-toxin producing *Escherichia coli* (STEC)) to assist in generating hypotheses to try and identify sources of infection. In effect, a pre-interviewed "control" database. Although data on specific food items and/or populations of interest had been extracted from this survey database on multiple occasions since the commencement of data collection, the data were yet to be fully analysed and formatted into a quick-access frequency table by food item. So that these data could be easily shared and used, it was proposed that I transform the data into a consumption frequency table by food item, stratified by age group, sex, and season. Following this, I conducted a series of different analyses on the data:

1. I described the results of the survey, focussing on characterising the consumption of high-risk foods for *Salmonella* infection to provide a better understanding of who might be at most risk of exposure to foodborne *Salmonella* infection in the Victorian population;
2. I assessed the difference in the consumption frequency of food items in the last seven days and in the last three days from interview to determine whether using a seven day trawler for *Salmonella* case interviews had any potential to hinder our ability to detect sources of infection; and
3. I tested the utility of the dataset in identifying potential sources of infection by comparing the results of a *Salmonella* case-case study conducted previously to a case-control methodology using case data from the case-case study and "control" data from the VFFS.

My role

I conducted all data transformation and analysis for this project, with methodological guidance from Zoe Cutcher and Joy Gregory.

Lessons learnt

This project provided a fantastic opportunity for me to become more closely acquainted with Stata, and to develop my analysis skills in working with large datasets. In particular, this project taught me:

- **New Stata skills** - including working with macros, tests of proportions, new tips and tricks for working in Stata more efficiently, and the value of a well-documented do-file; and
- **To recognise the difference between significant and meaningful** – much of my biostatistical training has focussed on statistical significance and its importance in defining a meaningful result. With such a large sample size in this project, I found that most of the statistical tests I ran returned a statistically significant result, especially when testing differences in proportions. However, this did not always mean that those differences were meaningful in the context of the data, so this project helped to solidify those concepts for me.

Public Health Impact

The VFFS provides valuable data not only for its primary purpose (to provide readily available data to assist in more quickly developing hypotheses for sources of infection during the investigation of *Salmonella* and other foodborne outbreaks), but also contains a wealth of data on food consumption patterns in the Victorian population that could be employed for many different purposes. Transferring the data into an easily accessible and interpretable format will allow it to be shared and used more broadly. It will also provide information on the frequency of consumption of high-risk foods for *Salmonella* infection, giving us a better understanding of who might be at most risk of infection from these foods. This project has also discovered large differences in the consumption of many food items between three and seven days, which may inform the design of future outbreak investigation questionnaires to improve our ability to identify the source of infection from the data collected. The re-analysis of the *Salmonella* case-

case study using VFFS data was able to identify the source of the outbreak, demonstrating the utility of the survey data for outbreak investigations.

Acknowledgements

Many thanks go to Zoe Cutcher for providing ceaselessly enthusiastic Stata tutorials and data analysis tips. You have introduced me to the wonders of macros, and though I may never understand them fully, they will serve me for years to come. Thanks also to Marion Easton for giving me the gift of a clean dataset, and to Joy Gregory for your wealth of knowledge and advice on everything foodborne disease. I would also like to acknowledge and thank:

- Loretta Vaughan and the Victorian Population Health Survey team for providing access to their recruited participants for the VFFS
- The Social Research Centre for conducting the VFFS
- Tina Petroulias for providing information on how the VFFS was conducted
- OzFoodNet for funding the VFFS
- And finally, all of the 4008 VFFS participants for donating their precious time to complete such a detailed survey

Abstract

Background: The Victorian Food Frequency Survey (VFFS) was conducted between November 2014 and October 2016 to provide data on the consumption frequency of certain food items amongst the Victorian population, so that this data could be compared to the food consumption frequencies of *Salmonella* cases and cases of other notifiable enteric pathogens to assist in developing hypotheses for sources of infection. The aims of this project were to transform the line-listed VFFS data into food frequency tables stratified by sex, age group, and season; to perform a descriptive analysis of the database examining food consumption by demographic distribution; to examine differences in consumption of food items in the last seven days versus the last three days from interview; and to demonstrate the utility of the VFFS in identifying potential sources of infection by comparing the results of a recent case-case study to a case-control methodology using "control" data from the VFFS.

Methods: The VFFS database was imported from Microsoft Excel into Stata IC 12.1 for the extraction of data for the reference table and the descriptive and case-control analyses. Graphs and tables were created in Microsoft Excel. Where relevant, tests of proportions and Pearson's chi-square tests were conducted in Stata to determine the significance of differences in food consumption between groups. The case-control analysis was conducted using case questionnaire data from a previously conducted case-case study, and data from the VFFS to act as "controls". Univariate analysis was performed to determine the odds of consuming the various food items for cases versus "controls". *P* values less than 0.05 were considered statistically significant, and a multivariate logistic regression analysis was performed including sex and all food items found to be significantly associated with illness in the univariate analysis.

Results: Consumption patterns in the VFFS data varied by food group. Takeaway foods were consumed by a higher proportion of males and young adults, while raw fresh produce was consumed by a higher proportion of females. Consumption of foods which have been associated with prior *Salmonella* outbreaks including raw cake batter, frozen chicken strips or nuggets, and peanut butter were consumed in the highest proportions by 0-4 year old children. Multiple commonly consumed foods had a difference of ≥10% between consumption in the last seven days and the last three days from interview. The

case-control analysis correctly identified bagged salad as being associated with illness, but also found red onion to be statistically significantly associated with illness.

Conclusions: This analysis has provided important information on the food consumption patterns of the Victorian population, indicating who may be most at risk of exposure to *Salmonella* and other enteric pathogen infections from various food sources. The production of an easily accessible food frequency table will facilitate a more timely response to acute foodborne outbreaks in Victorian and possibly across Australia, making the VFFS a valuable tool in the protection of public health. The use of a seven day food trawler when interviewing cases of salmonellosis should be reviewed to ensure associations are not hidden by excess food consumption data.

Introduction

As has been described in more detail in chapters two and three of this volume, *Salmonella* infection is a significant cause of gastrointestinal illness in Australia. In 2014 there were 16,358 notifications of *Salmonella* infection in Australia, accounting for just over 40% of all notifiable gastrointestinal disease cases reported to the Australian National Notifiable Diseases Surveillance System (NNDSS).[1] This pattern is reflected in Victoria, which in 2016 reported 4089 cases of *Salmonella* infection, an increase of 23% on the Victorian five year mean.[2]

Transmission of *Salmonella* infection in humans is predominantly through the consumption of food and/or beverages (particularly those of animal origin) contaminated with the faeces of an infected person or animal.[3] *Salmonella* is the causative organism for a considerable proportion of foodborne outbreaks in Australia each year, causing 40% of foodborne outbreaks in 2011 nationally, and 37-69% of foodborne outbreaks in Victoria between 2012 and 2016.[2,4-8] As such, it is important that health departments are able to quickly identify the source of a *Salmonella* outbreak in order to prevent further cases.

In 2000 Australia established OzFoodNet (OFN); a network of epidemiologists in each state and territory health department who work collaboratively to facilitate integrated country-wide surveillance, outbreak investigation, and control of foodborne diseases.[9] In Victoria, the epidemiological investigation of a *Salmonella* cluster or outbreak is coordinated by the OFN epidemiologists at the Victorian Department of Health and Human Services (DHHS). DHHS Public Health Officers (PHOs) and OFN surveillance officers contact notified cases and administer a standardised questionnaire (Appendix 1). This questionnaire collects information the case's illness (onset, symptoms, treatment etc.), recent travel, contact with other possible sources of infection (consumption of rainwater, contact with animals and sewage etc.), and food consumption. Depending on the type of investigation, a three day food history (detailing all food items consumed in the last three days from the day of interview) and/or a seven day food trawler questionnaire (where the case is asked whether they have consumed any of a list of food items in the last seven days) are completed (Oral communication, OzFoodNet Victoria Epidemiologist, September 2017).

In rare instances, the source of infection in a cluster or outbreak is clearly identified. This usually only occurs when cases report having eaten at a common place, such as a particular restaurant, or having consumed an uncommon food item like unpasteurised milk, in their incubation period. However, when the source of infection is a commonly consumed food item, such as chicken or tomatoes, it is more difficult to identify the source of infection, which inhibits the ability of the health department to prevent further exposure and illness. In this situation, one solution is to compare the frequency with which cases consume certain food items to the frequency with which well people consume the same food items over the same time period. This can be done by conducting retrospective case-control or cohort studies, but as these studies are very time and resource intensive and require a working hypothesis for the source of infection, it is often not feasible or possible to conduct them.

To assist in developing hypotheses for these cluster and outbreak investigations, OzFoodNet Victoria commissioned the Victorian Food Frequency Survey (VFFS). The survey was designed to collect the same food consumption information as collected by the standardized *Salmonella* questionnaire. The aim of the survey was to collect food frequency information from well Victorian residents to which *Salmonella* case questionnaire responses could be compared, assisting OzFoodNet to more rapidly develop hypotheses for sources of infection during investigations. A total of 4008 participants were interviewed between November 2014 and October 2016. Data from the survey have been used during multiple outbreak investigations in Victoria and in other Australian states.

Until the commencement of my project, where required, food consumption data had been extracted from the line-listed VFFS database and converted to food frequency tables, as the entire dataset had not been transformed into food frequency tables. The dataset had also not been descriptively analysed, and no tests of its utility performed. As such, the aims of this data analysis project were threefold:

1. To create food frequency tables containing all of the VFFS food consumption data listed by food item, stratified by seven day and three day consumption, age group, season, and sex, so that this data is readily accessible for analysis and distribution where required;

2. To perform a descriptive analysis of the data, examining food consumption by demographic variables; most commonly consumed food items; consumption of 'high risk' food items for *Salmonella* and other foodborne infections such as eggs, chicken meat, and raw fresh produce; and differences in consumption of food items in the last seven days versus the last three days from interview; and

3. To demonstrate the utility of the VFFS in identifying potential outbreak sources by comparing the results from a previously conducted *Salmonella* case-case study to results obtained from employing a case-control methodology using case data from the case-case study and "control" data from the VFFS.

Methods

VFFS

Interviews for the VFFS took place between November 2014 and October 2016 and were conducted by The Social Research Centre, funded by OzFoodNet Victoria. Potential VFFS participants were recruited from a 'control bank' of Victorian residents who had participated in the Victorian Population Health Survey (VPHS) in 2014 and 2015 and who agreed at that time to be registered in a database for participation in further health surveys. Participants for the 2014 and 2015 VPHS surveys were recruited through random digit dialling (RDD), using a RDD sample of Victorian landline and mobile telephone numbers provided by a commercial list provider. Participants were required to be residents of a private dwelling in Victoria who were 18 years or older. Victorian residents who were under 18 years old, who were homeless or itinerant, in a hospital or institution, who were unable to complete the survey due to disability or frailty, or who spoke a language other than the eight community languages for which translators were provided (Italian, Greek, Mandarin, Cantonese, Vietnamese, Arabic, Turkish and Serbo-Croatian), were excluded from the survey.

Potential VFFS participants were selected from the VPHS database to reflect the basic demographics (age, sex, and residential (metropolitan and non-metropolitan) distributions) of *Salmonella* infections notified to the DHHS between 2008 and 2013. As the VPHS did not recruit participants under 18 years of age, consumption frequency information for children was collected by asking those who were contacted to participate in the VFFS whether there were any children under the age of 18 years living

in their household, and depending age group quota requirements, then asking whether they would complete the survey on the child's behalf instead of completing it for themselves. For children aged 15-17 years, parents were asked for consent to interview the child, and the child was then interviewed directly. If a parent did not want to complete the questionnaire on behalf of their child or did not want their child to participate, they were then asked if they wanted to participate themselves.

Given the seasonality of many food items, interviews were conducted uniformly over the two year time period of the VFFS, with approximately the same number of interviews completed in each month. VFFS questionnaires were administered via computer-assisted telephone interviewing (CATI). When first contacted, participants were asked whether they (or the child they were answering for) had experienced gastrointestinal symptoms of vomiting and/or diarrhoea in the previous seven days. If they had, they were ineligible to participate in the study and either another household member (who had not been sick) was interviewed, or the interview was terminated. If eligible to continue, participants were asked whether they had consumed a list of specific food items within the seven days prior to their interview. If they answered 'yes' to having eaten any of these food items, they were then asked whether they had eaten this food item within the previous three days. For some foods, further questions were asked about how the foods were eaten (e.g. raw or cooked) and in what state the foods were purchased (e.g. pre-packaged or loose from a deli). The 253 food items included in the questionnaire were the same as those in the standardised *Salmonella* seven day food trawler questionnaire used to interview cases of *Salmonella* infection in Victoria (Appendix 1). Interviews were not conducted in languages other than English.

Food frequency tables

Interview data from the VFFS were provided to OzFoodNet Victoria epidemiologists in a line listed Microsoft excel file, complete and with no missing data. This data was imported into Stata IC 12.1 (StataCorp, 2011. College Station, TX) for the extraction of data for the food frequency tables and the descriptive and case-control analyses.

Sixteen infant participants whose parents reported that they only drank breast milk in the seven days prior to interview were excluded from the food frequency tables and from all food-based analyses, leaving 3992 participants. For the purposes of these

analyses, in rare instances where a participant had refused to answer a question, these responses were considered an unknown response. Unknown responses accounted for less than 1% of all participant responses for any food item.

To create the food frequency tables, the data was first analysed to determine whether there were statistically significant differences in the consumption of major food groups by month or season of interview, in order to decide whether the data over the two year period could be pooled by season. Data were then extracted from Stata by age group, sex, and season (pooled) for each food item and transferred into Microsoft Excel frequency tables. Within the food frequency Excel workbook, eight tables (in eight separate tabs) were created: one for all participants, and seven different tabs for each age group. The seven age groups used were the same as those used in the VFFS survey, as the age in years of participants was not collected. In each table (tab) consumption frequency data was listed by food item and separated into season blocks. The data was grouped by seven day and three day responses with Yes, No, and Unknown frequencies, and an additional column detailed the proportion who answered yes to consuming the food item. Frequencies were provided for each sex separately and both sexes together. A cumulative block for all seasons combined was also included in each table.

Descriptive analysis

The descriptive analysis was performed in Stata IC 12.1 and graphs and tables were created in Microsoft Excel. Analyses were performed using only consumption data from the last seven days from interview to be consistent with the *Salmonella* trawler questionnaire, except where seven and three day food histories were compared. Where relevant, tests of proportions and Pearson's chi-square tests were conducted in Stata to determine the significance of differences in food consumption between groups. Where relevant for these tests, winter was used as the reference season, and the 18-34 year age group was used as the reference age group.

Although a major food group, fruits and vegetables were not included in the initial 'skip' questions applied to the other major food groups in this study (meat, deli meat, fish, seafood, milk, cheese, eggs, nuts, and takeaway food), so equivalent variables were created for the purpose of including these foods in the analyses of the other major food groups. A participant was considered to have consumed any fruits or vegetables in the

last seven days if they answered yes to consuming any individual fruit or vegetable food item in the last seven days from their interview. Anyone who did not answer 'yes' to eating any fruit or vegetable food items in the last seven days before their interview has been assumed not to have eaten them for the purposes of this analysis, but it is acknowledged that some of this data may actually be 'unknowns' as opposed to definitive 'no' responses. It is also important to note that as participants were not asked whether the fruit items they ate were consumed raw or cooked, for the purposes of this analysis it is assumed that all fruits have been eaten raw. However, it recognised that this may not always be the case, especially for infants who often consume fruit which has been cooked and puréed.

Case-control analysis

The case-control analysis was conducted using data from outbreak investigation questionnaires administered to *Salmonella* Anatum cases at the time of the original outbreak and data from the VFFS as "controls".

The outbreak of *Salmonella* Anatum occurred between December 2015 and February 2016, and was associated with the consumption of bagged salad mix. There were 311 confirmed cases identified across Australia, of whom 79% (n=247) were Victorian residents. A case-case study was conducted at the time of the outbreak to test the null hypothesis that there was no association between confirmed cases of *Salmonella* Anatum and consumption of bagged salad mix. "Controls" in the case-case study were laboratory-confirmed cases of cryptosporidiosis or campylobacteriosis with specimen collection dates between January and February 2016. Cases were defined as a person who had *Salmonella* Anatum with the outbreak sequence (on whole genome sequencing) isolated from a faecal specimen, who was a resident of Victoria with a specimen collection date after 14 January 2016 and before 11 February 2016. Eighty-eight "controls" were recruited, frequency-matched by age to the 64 recruited cases.

For the case-control analysis using VFFS data, "controls" were all VFFS participants who were interviewed in the months of December or January (representing the months that the majority of cases had their onset dates) and who were over 18 years of age, as all cases were aged 19 years or over. As the initial case-case study questionnaire only contained 46 variables from the standardized seven-day trawler, only food items

included in both datasets were included in the case-control analysis. As it had been for the original case-case study, the null hypothesis of the case-control analysis was that there was no association between confirmed cases of *Salmonella* Anatum and consumption of bagged salad mix.

Case and "control" data were imported from Microsoft Excel into Stata IC 12.1 for analysis. As performed in the original case-case study, univariate analyses, including the calculation of odds ratios, 95% confidence intervals, and 2-sided Fisher exact *P* values were performed to determine the odds of consuming the various food items for cases versus "controls". *P* values <0.05 were considered statistically significant, and a multivariate logistic regression analysis was performed including sex and all food items found to be significantly associated with illness in the univariate analyses.

The above analyses were performed on two different datasets. One dataset included all cases and all participant records in the VFFS meeting the above criteria as "controls". The other dataset included all cases but only 88 randomly selected VFFS "controls" meeting the above criteria, frequency matched by age to cases, as per the original study design. The VFFS participant records included in this dataset were selected by randomly generating a number for each "control" record in Microsoft Excel, sorting these numbers by smallest to largest by age group, and selecting the first records in each age group as proportional to cases.

Ethics

The VFFS received ethics approval from the Victorian DHHS Human Research Ethics Committee (HREC), and as this project was not outside the scope of the VFFS' approved purpose, ethics approval was not required for this project.

Results

Food frequency tables

As the food frequency tables created were very large and could not be easily displayed in this report, an example of the layout of the food frequency tables has been provided in Figure 1 below, with just one season and a selection of food items represented.

Figure 1: Example of layout of VFFS food frequency tables

FOODS	Summer																							
	Last 7 days												Last 3 days											
	All persons				Males				Females				All persons				Males				Females			
	Yes	No	Unk	% Yes	Yes	No	Unk	% Yes	Yes	No	Unk	% Yes	Yes	No	Unk	% Yes	Yes	No	Unk	% Yes	Yes	No	Unk	% Yes
Deli Ham																								
Pre-packaged																								
From deli or sliced to order																								
Unknown																								
Celery																								
Raw																								
Cooked																								
Unknown																								
Honeydew melon																								
Watermelon																								
Peanuts																								
Almonds																								

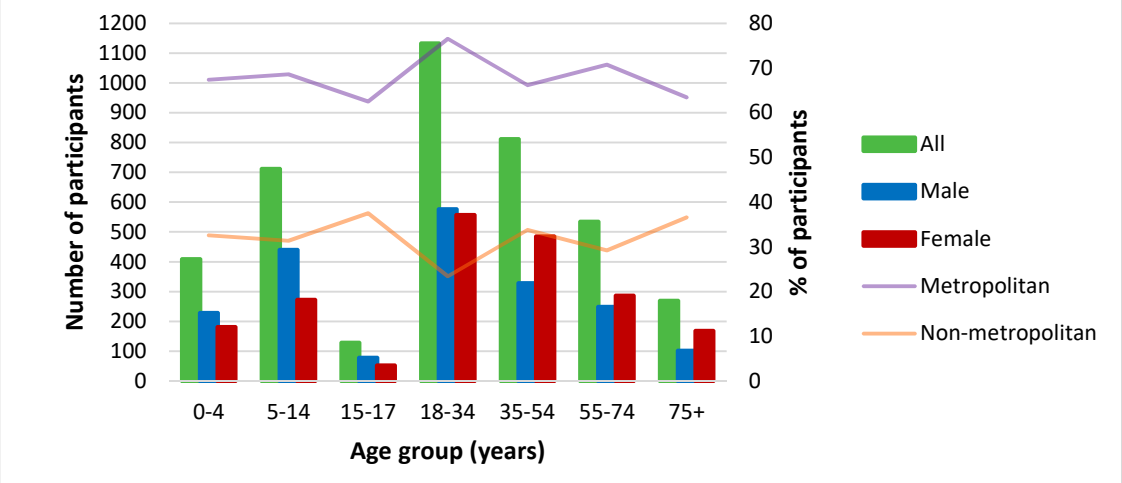
Descriptive analysis

Participant demographics

The VFFS database contains 4008 records. Sixteen infants were excluded from these analyses as their parents reported they were exclusively breastfed, leaving 3992 records.

Overall the sex distribution of the dataset is equal (1996 males and females), but this does vary by age group, with a higher proportion of males in the younger age groups, and a higher proportion of females in the older age groups (Figure 2). The sex distribution by age group remains similar across the seasons. The ratio of non-metropolitan to metropolitan participants was 1:2.3 overall, and this remained stable over the seasons. However, the ratio did vary across age groups, from 1:1.7 in the 15-17 year olds to 1:3.3 in the 18-34 year olds (Figure 2).

Figure 2: Number of VFFS observations by age group, sex, and residential location



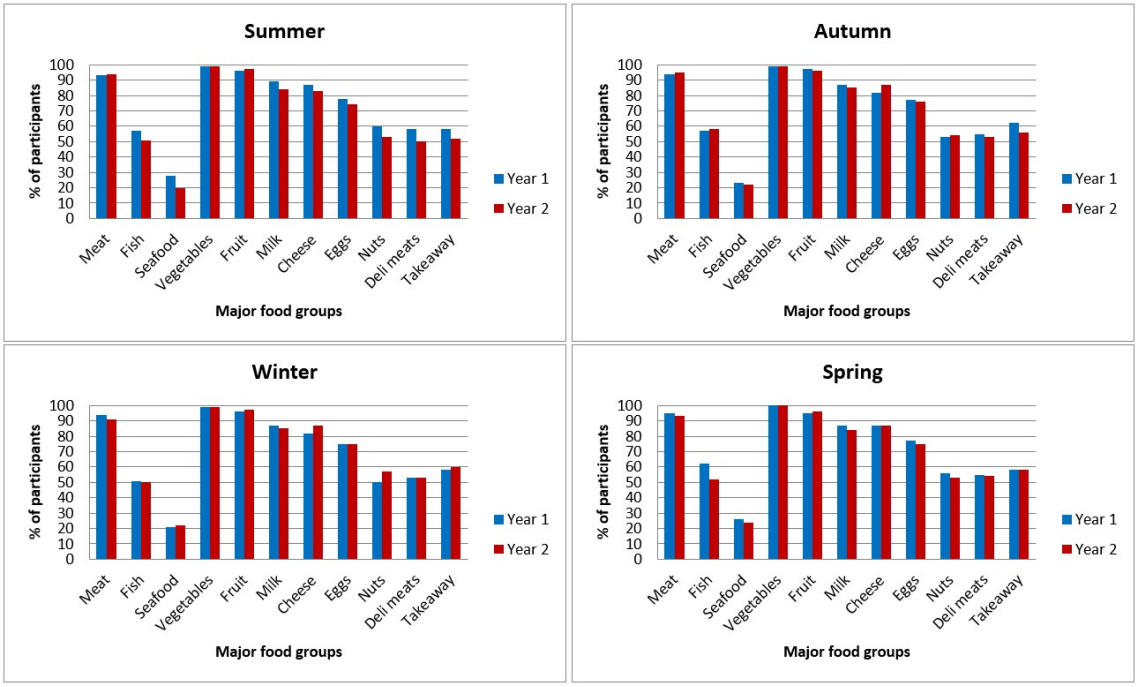
Consumption of major food groups

Consumption tables for major food groups by season, sex, age group, and location with *P* values for tests of difference in consumption can be found in chapter Appendix 2.

By year and season

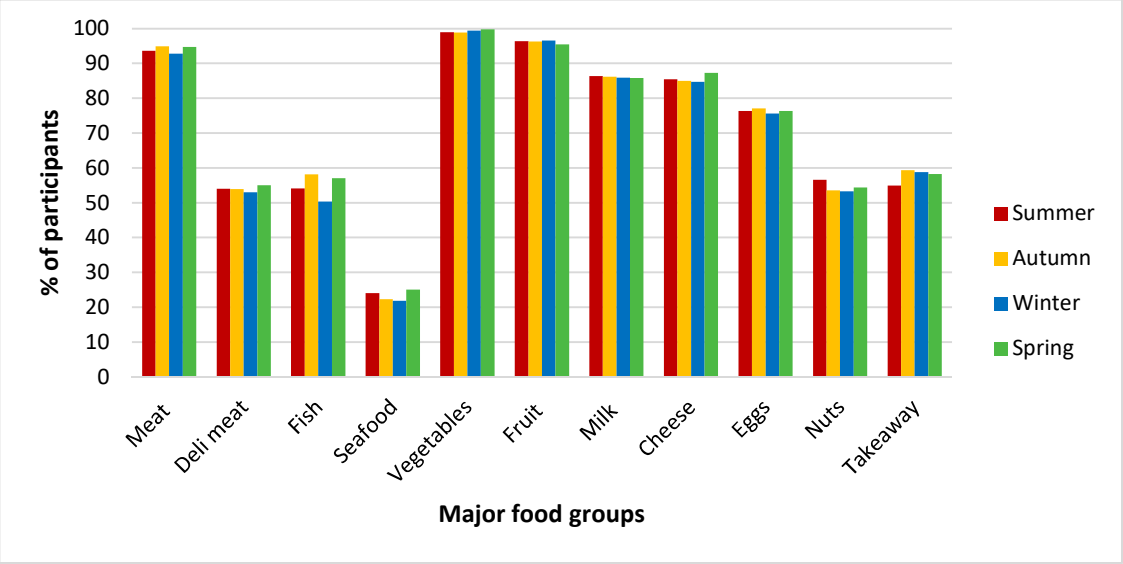
The differences in the consumption proportions of major food groups between the two years by season was minimal (Figure 3). As such, it was decided that the seasons in the two years could be pooled in the reference table and for all following analyses.

Figure 3: Differences in the proportion of people who consumed major food groups by season and year of data collection



No seasonality in the consumption of major food groups was observed (Figure 4). Results of a chi square test found that only the consumption of fish was significantly different over the seasons as a whole (*P* value = 0.002). Looking closer by seasons individually, the reason for this overall difference was a significantly different consumption of fish in both autumn and spring compared to winter (Figure 4). Although significant, these differences in consumption by season were not large, with fish being consumed by 50% of participants in winter, and by 58% and 57% of participants in autumn and spring respectively.

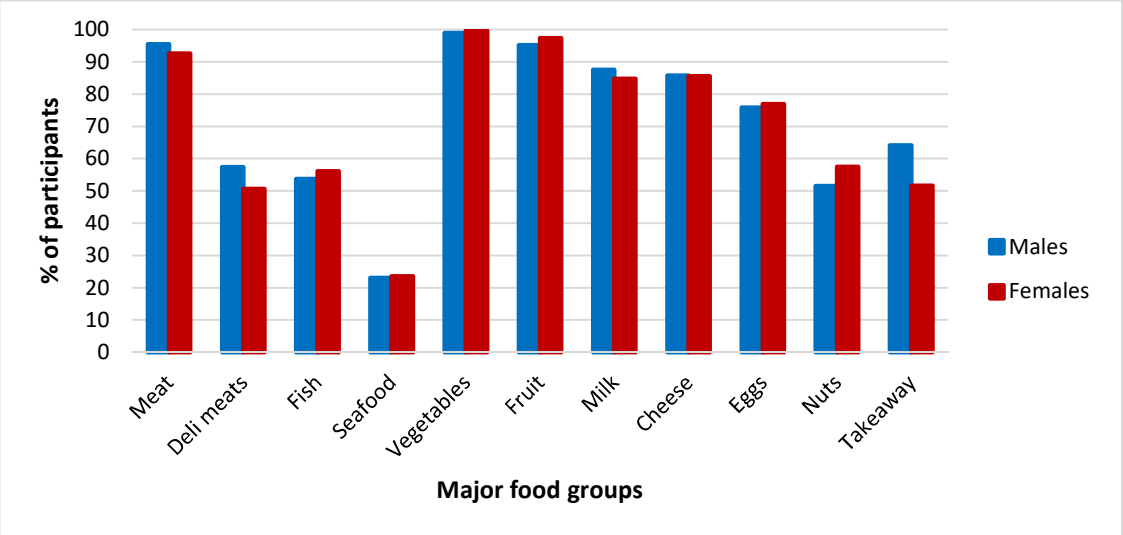
Figure 4: Consumption of major food groups by season



By sex

Differences in consumption proportions between males and females were statistically significant for most major food groups. Males consumed significantly more meat, deli meat, and milk, while females consumed significantly more vegetables, fruit, and nuts. However, for the most part these differences in consumption proportions were small (Figure 5). The largest difference observed was in the consumption of takeaway foods, with 64% of males and only 52% of females reporting consumption of takeaway foods in the last seven days.

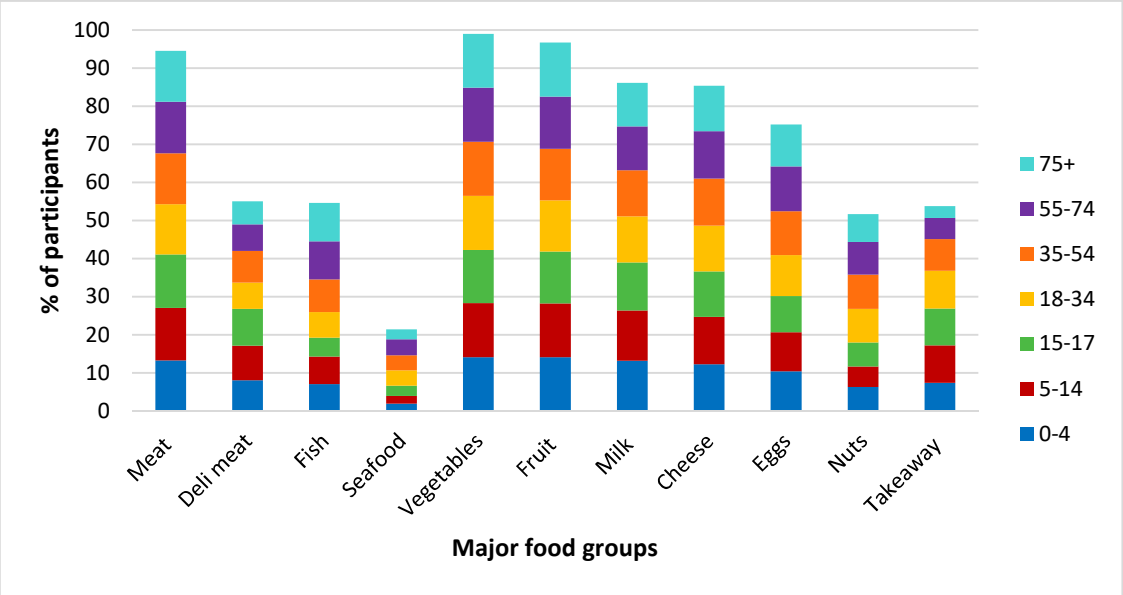
Figure 5: Consumption of major food groups by sex



By age group

Consumption proportions for the majority of major food groups were also found to be significantly different between age groups, however as with gender, although significant many of these differences were not large (Figure 6).

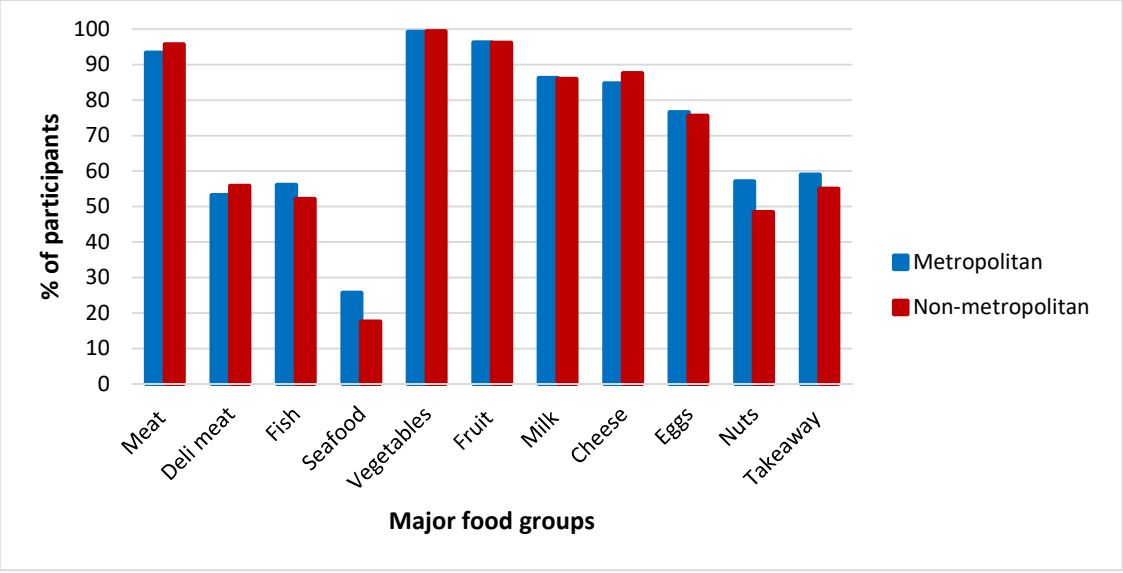
Figure 6: Consumption of major food groups by age group



By residential location

Differences in the consumption of foods between metropolitan and non-metropolitan participants varied by food group (Figure 7). The largest and most significant differences were in the consumption of seafood and of nuts, which were consumed by 8-9% more metropolitan dwelling participants than non-metropolitan participants.

Figure 7: Consumption of major food groups by residential location



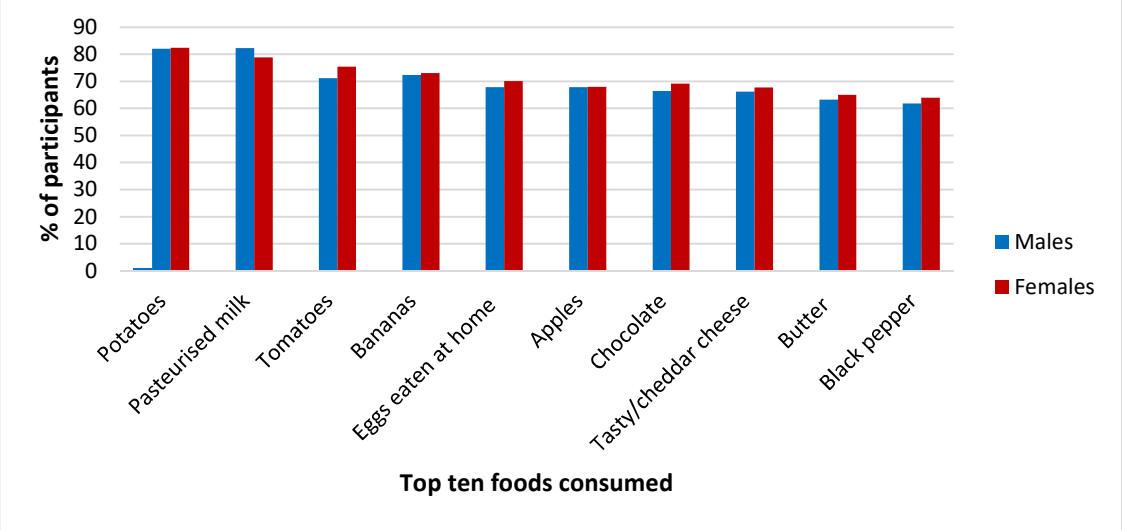
Most commonly consumed foods

Consumption tables for the top twenty foods consumed by sex, season, and age group can be found in chapter Appendix 3.

By sex

The top twenty food items consumed by VFFS participants did not differ substantially between males and females. Indeed, there was minimal difference in the top ten food items consumed by males and females (Figure 8), though the following ten food items did start to differ slightly, with more females consuming yogurt, cucumber, strawberries and pumpkin, and more males consuming beef mince and other beef products.

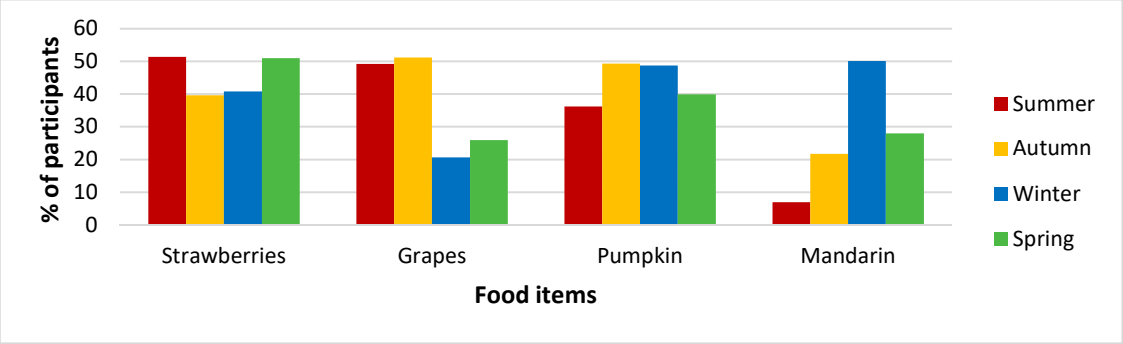
Figure 8: Consumption of top ten most consumed food items by sex



By season

This situation was similar when the top twenty food items were examined by season. The first 17 food items were largely the same and were consumed by similar proportions of participants across all seasons. The final three items in the list, however, were quite different: in summer and spring strawberries were consumed by a higher proportion of participants; grapes were consumed by a higher proportion in summer and autumn; mandarins were consumed by a much higher proportion in winter; and pumpkin was consumed by more participants in autumn and winter (Figure 9).

Figure 9: Consumption of selected food items by season

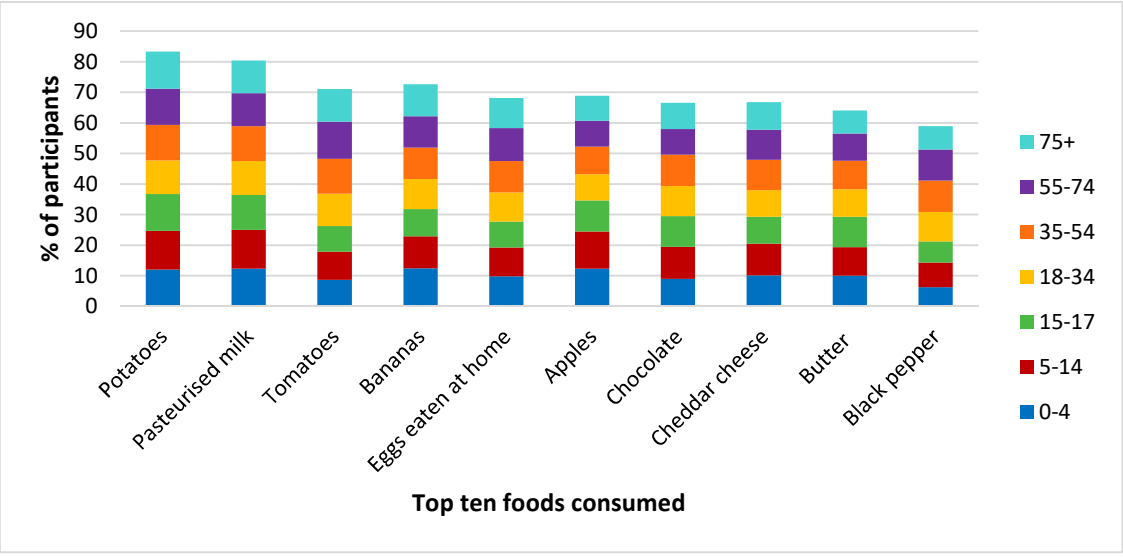


By age group

The top twenty food items varied to a greater degree across age groups, both in terms of consumption proportions and food items included in the list. While the food items included in the top 10-15 were largely similar for each group, consumption proportions for each food item were quite different across the age groups (Figure 10). For example, bananas were consumed by 73% of participants overall, but this ranged from 87% amongst 0-4 year olds, to 62% amongst 15-17 year olds. Apples were also consumed by a higher proportion of those aged 0-14 years.

As observed between the sexes and the seasons, variation increased between age groups further down the top twenty list. A much higher proportion of 0-4 year olds consumed grapes and sultanas than all other age groups, while a much higher proportion of 5-14 year olds and 15-17 year olds consumed ice-cream from a tub. A higher proportion of those aged between 15 and 34 consumed commercial bottled water, and celery was consumed by a much greater proportion of those aged 75 or over.

Figure 10: Consumption of top ten most consumed food items by age group

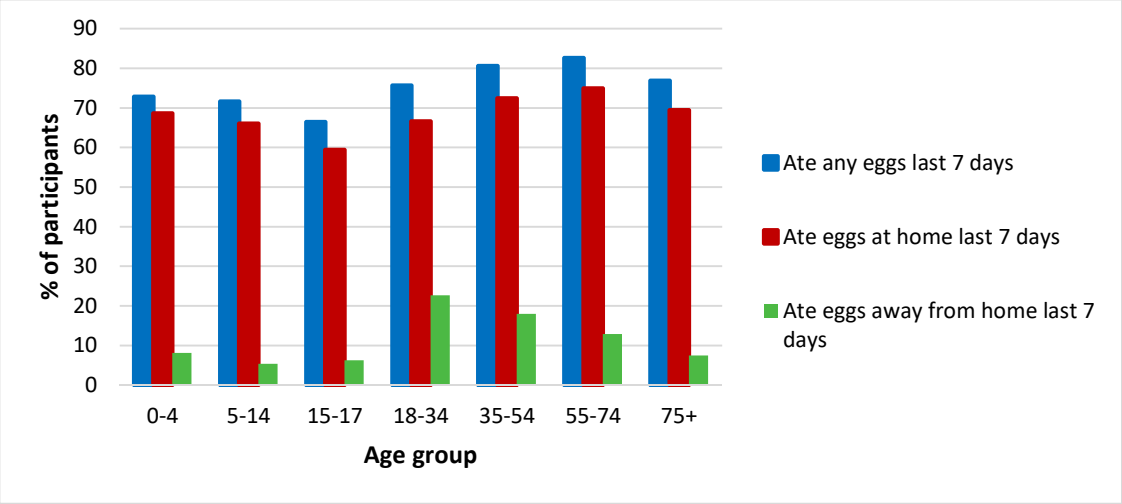


Consumption of high-risk foods for *Salmonella* infection

Eggs

The consumption of any eggs in the last seven days from interview was not significantly different between the sexes, nor between the seasons (Figures 4 and 5), but did vary to a greater extent between age groups (Figure 11).

Figure 11: Proportions of egg consumption by age group and consumption location



Eggs that were eaten at home were relatively consistently consumed across all seasons and by both sexes. Across age groups, eggs were eaten at home by a marginally higher proportion of participants in the 35 years and over age groups than in the younger age groups (Figure 11). Eggs eaten away from home were also consumed consistently across the sexes and the seasons, though were consumed by many fewer participants. Again, consumption was highest in the older age groups, particularly those aged between 18 and 54. The vast majority of eggs consumed by participants overall, both at home and away from home, were chicken eggs. Only 0.6% of participants reported eating duck, quail, or unknown eggs at home, and only 0.2% reported eating any of these other eggs away from home.

The most popular method of cooking eggs differed by age group and by consumption location (at home or away from home). Eggs eaten at home were predominantly scrambled for those aged 0-4, fried for those aged 5-74, and boiled or poached for those aged 75 years and above (Figure 12). A higher proportion of those in younger age groups (aged 0-14) consumed their eggs eaten at home with a hard consistency than with a soft or runny consistency, while a soft consistency was more popular in participants aged

over 75 years. Those aged 18-34 years had the least difference between the consistencies of eggs consumed. For eggs eaten away from the home, a hard consistency was again more popular in participants 0-14 years of age, but also in those aged 35 years and above (Figure 13). Runny eggs eaten away from home were consumed most by those aged between 18 and 74 years of age, and the most popular method of cooking for those aged 18-54 changed from frying to poaching.

Figure 12: Cooking method and consistency of eggs eaten at home by age group

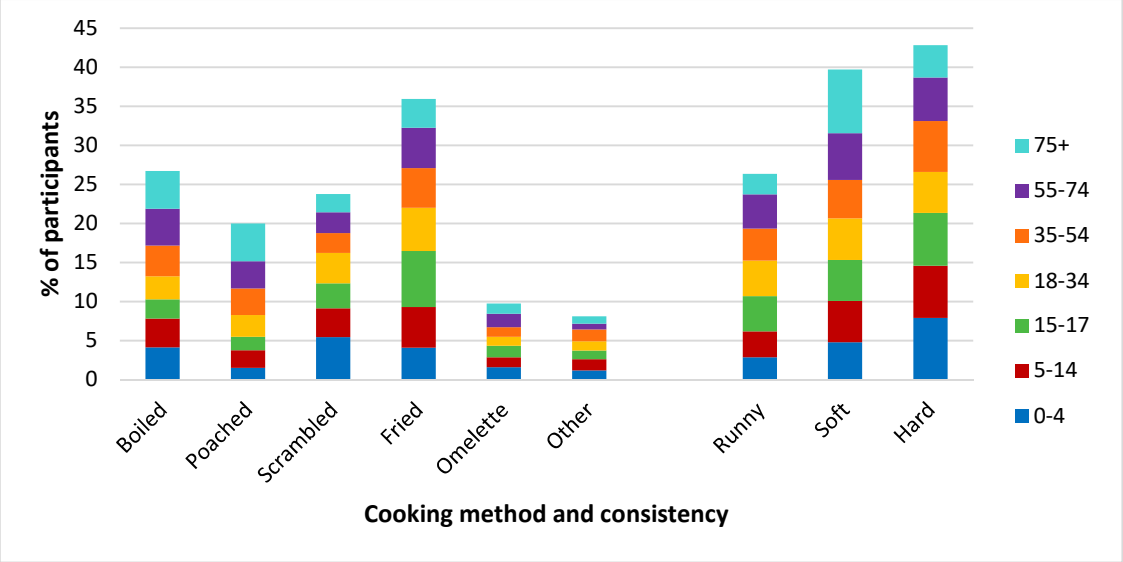
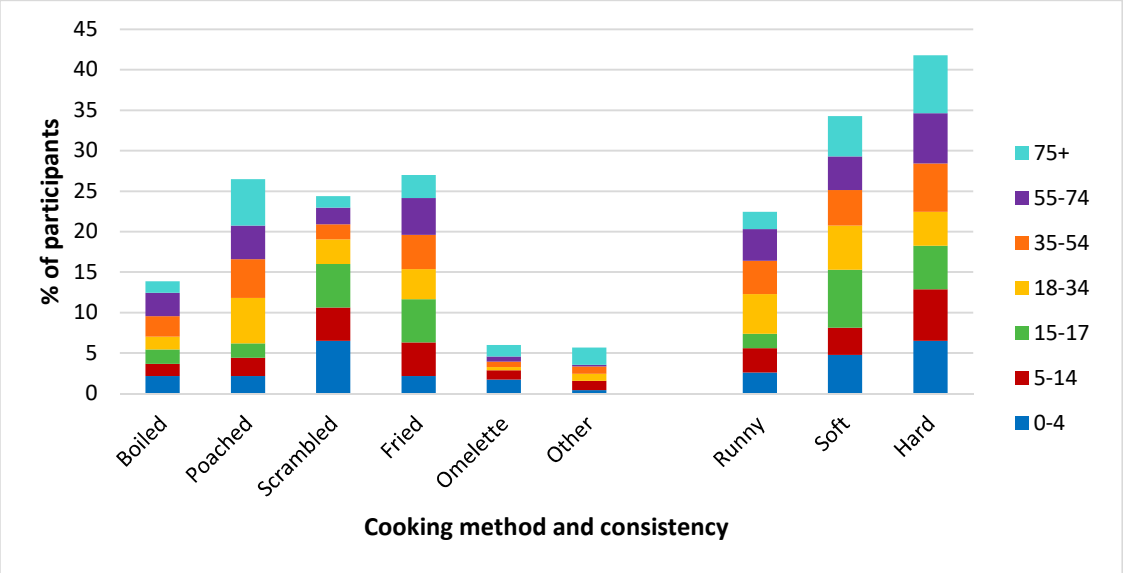


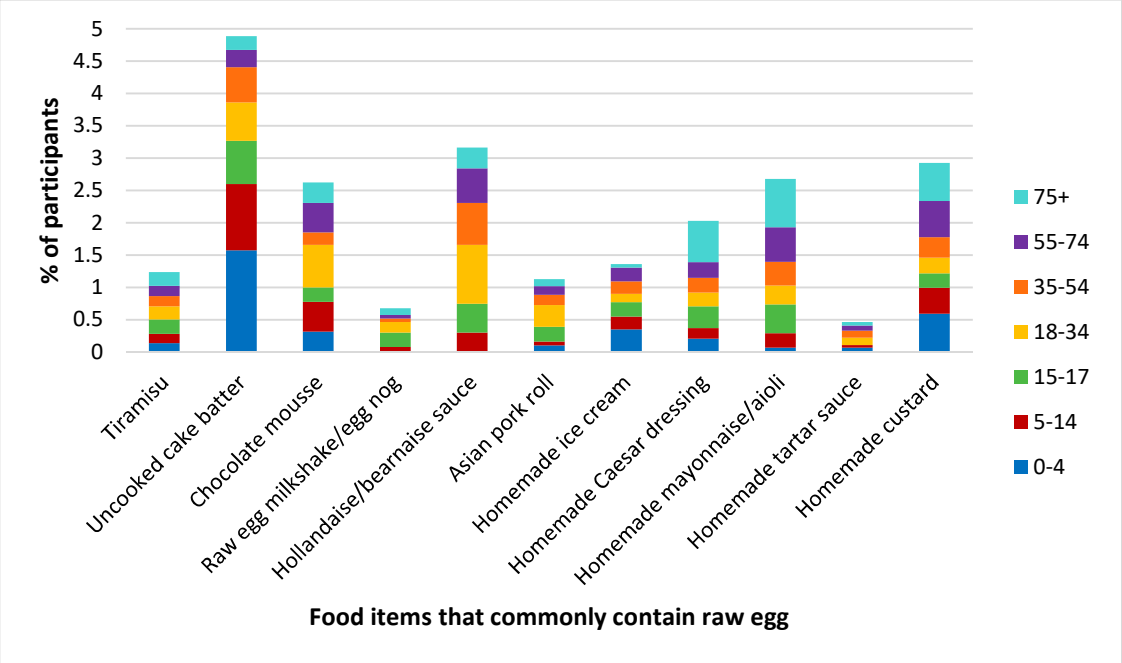
Figure 13: Cooking method and consistency of eggs eaten away from home by age group



Overall, 1.9% of VFFS participants reported that any of the eggs they had consumed had been raw, with those in the 18-34 years and the 5-14 years age groups having the highest proportion of raw egg consumption at 2.7%, and those aged 75 years and over having the lowest at 0.7%. Food items that often contain raw or low-cooked eggs were

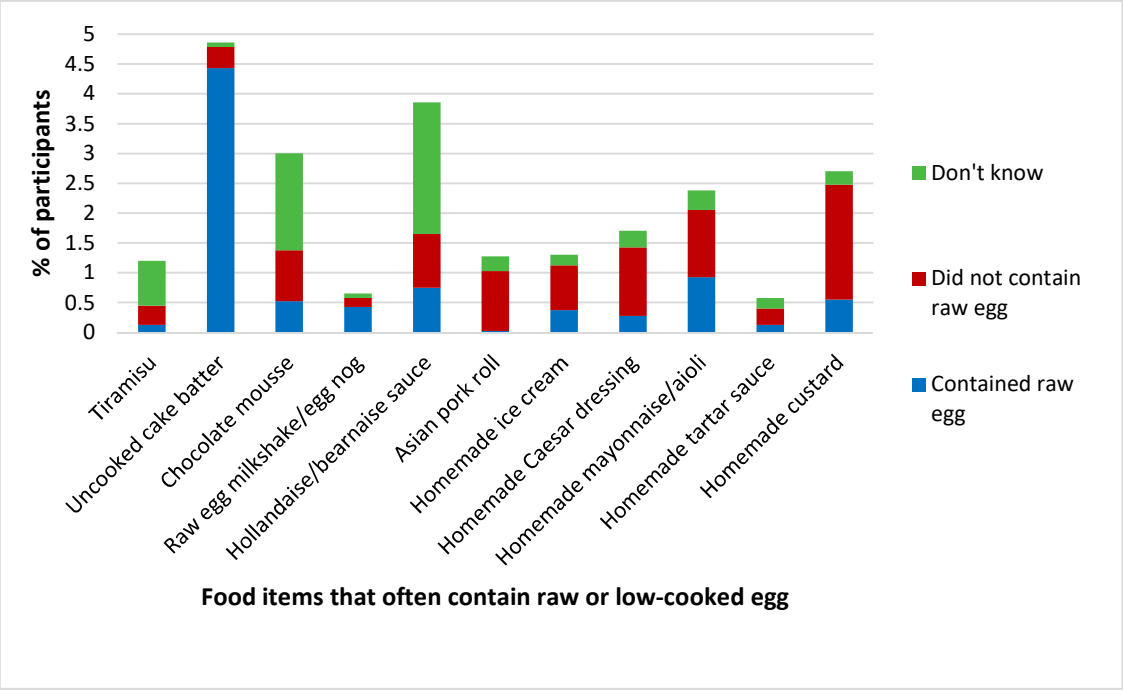
consumed by 19.6% of VFFS participants overall, but consumption of these items also varied by age group (Figure 14). Uncooked cake batter was consumed by the highest proportion of participants overall (4.9%), and by age group was consumed by the highest proportion of participants in the 0-4 and 5-14 year age groups, declining in the older age groups. Hollandaise/béarnaise sauce was the next most consumed overall, with a clear peak in the 18-34 year age group. Chocolate mousse was the third most commonly consumed, with consumption again highest in the 18-34 year age group.

Figure 14: Consumption of food items that often contain raw or low-cooked eggs by age group



The extent to which these food items were known to contain raw eggs when consumed varied by food item (Figure 15). Overall, 39.4% of VFFS participants that had consumed foods made with raw egg reported that they were aware the food item contained raw egg, while 27% didn't know whether it had. By item, almost 5% of VFFS participants consumed uncooked cake batter, and 91% of those participants were aware that it contained raw eggs when consumed. Conversely, almost 4% of participants consumed hollandaise/béarnaise sauce, and only 19.5% of them stated that that they knew it contained raw eggs, while 57.1% did not know whether it contained raw eggs. This was similar for tiramisu and chocolate mousse, with more than half of those who consumed these items not knowing whether they contained raw eggs when consumed (Figure 15).

Figure 15: Consumption of food items that often contain raw or low-cooked eggs by whether participants knew if the item contained raw egg when consumed

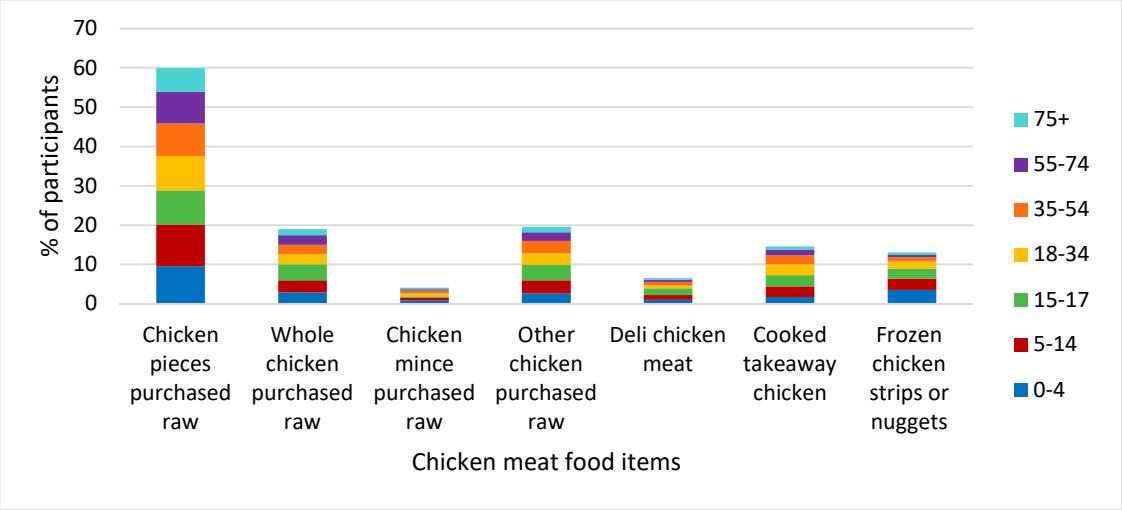


Chicken meat

Overall, 78.5% of VFFS participants reported having consumed a chicken meat food item (including whole chicken, chicken pieces, chicken deli meat, and takeaway chicken) in the seven days prior to interview. There was no difference in consumption greater than 5% between males and females, nor between the seasons. Consumption proportions of any chicken meat food items overall and individual chicken meat items did vary to greater extent by age group (Figure 16).

Almost 90% of participants aged 5-14 years consumed a chicken meat food item in the last seven days from interview, while only 58% of those aged 75 years or over did. Chicken pieces purchased raw and prepared and cooked at home was the most commonly consumed chicken meat food item in all age groups, while chicken mince was the least commonly consumed by all. Cooked takeaway chicken was eaten by higher proportions of participants in the 15-17 and 18-34 year age groups, and frozen chicken strips or nuggets were consumed by a much greater number of 0-4 year olds (Figure 16).

Figure 16: Consumption of chicken meat food items by age group



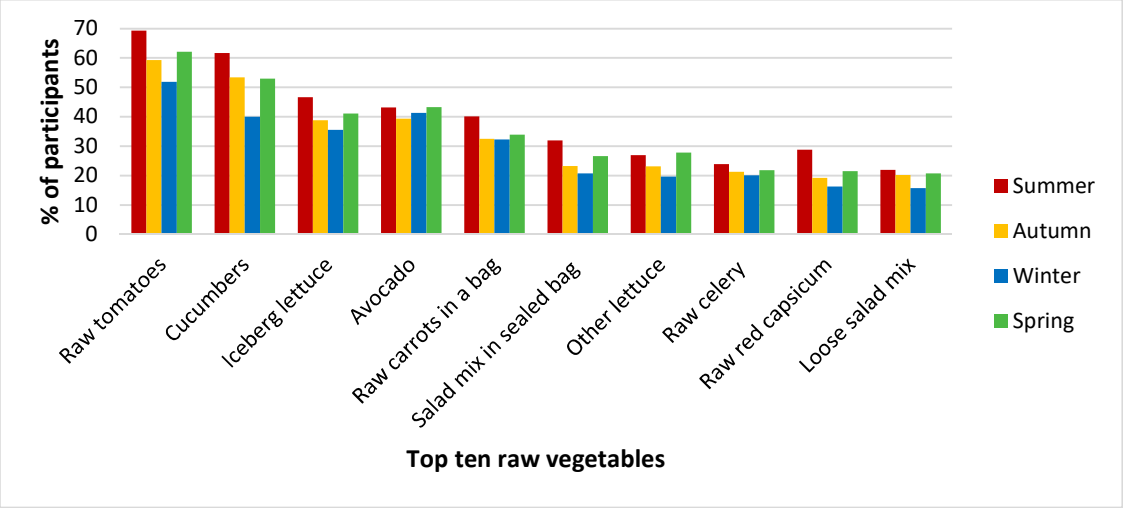
For chicken meat food items purchased raw and cooked at home, information was also collected on whether the meat was pink when consumed. Overall, 5% of VFFS participants ate the chicken meat they had purchased raw and prepared at home pink, while 0.9% didn't know whether the meat was pink when they consumed it. There was no significant difference in consumption of pink meat between males and females, nor between age groups. Chicken mince was consumed pink by the highest proportion of people who ate it at 6.5%, while for all other meats purchased raw and prepared at home this proportion was closer to 4%.

Raw fresh produce

Overall, 99% of VFFS participants ate raw produce in the last seven days from interview, with females eating only marginally more than males (99.6% vs 98.5%). Raw vegetables were consumed by 92.5% overall, with females again consuming slightly more than males (94.3% vs 90.8%), and raw fruit was consumed by 99.3% overall (females 99.6%. males 98.9%).

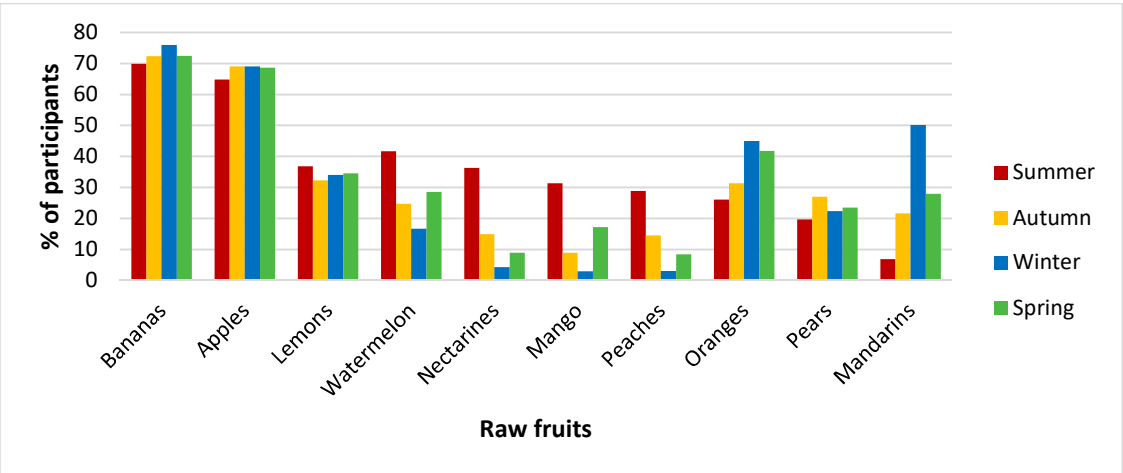
Consumption of any raw produce overall did not vary by season, and neither did the consumption of raw vegetables. The top ten raw vegetables consumed by participants overall only varied slightly by season, and this was true for almost all raw vegetables consumed (Figure 17).

Figure 17: Consumption of the top ten raw vegetables by season



The consumption proportions for raw fruit, however, varied to a greater extent between the seasons. Although bananas and apples retained the top two positions across all seasons, fruits further down the list changed considerably, especially between summer and winter (Figure 18). For example, nectarines and mangoes were consumed by 31.4% of participants in summer, but did not make the top ten raw fruits consumed in any other season. Conversely, mandarins were consumed by a much higher proportion of participants in winter (50.1%) compared to autumn and spring (21.7% and 28% respectively).

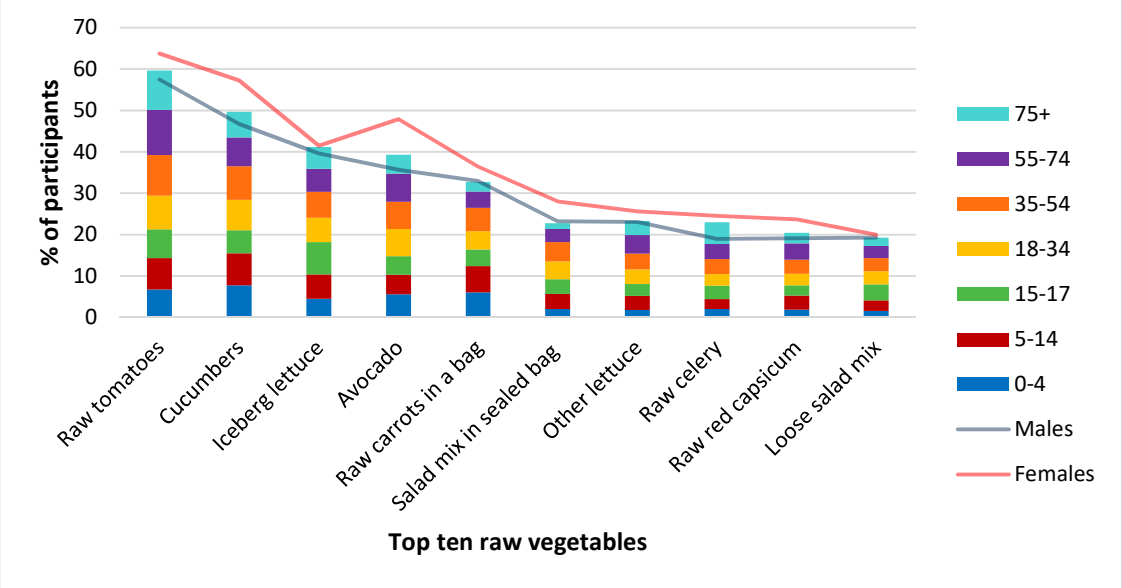
Figure 18: Consumption of selected raw fruits by season



Consumption of raw vegetables also did not vary substantially by age group, though loose salad mix was consumed by a higher proportion of those in the 18-34 and 35-54 year age groups, and raw tomatoes were consumed by a higher proportion of those in the 55-74 year age group (Figure 19). The order of the top ten raw vegetables was also

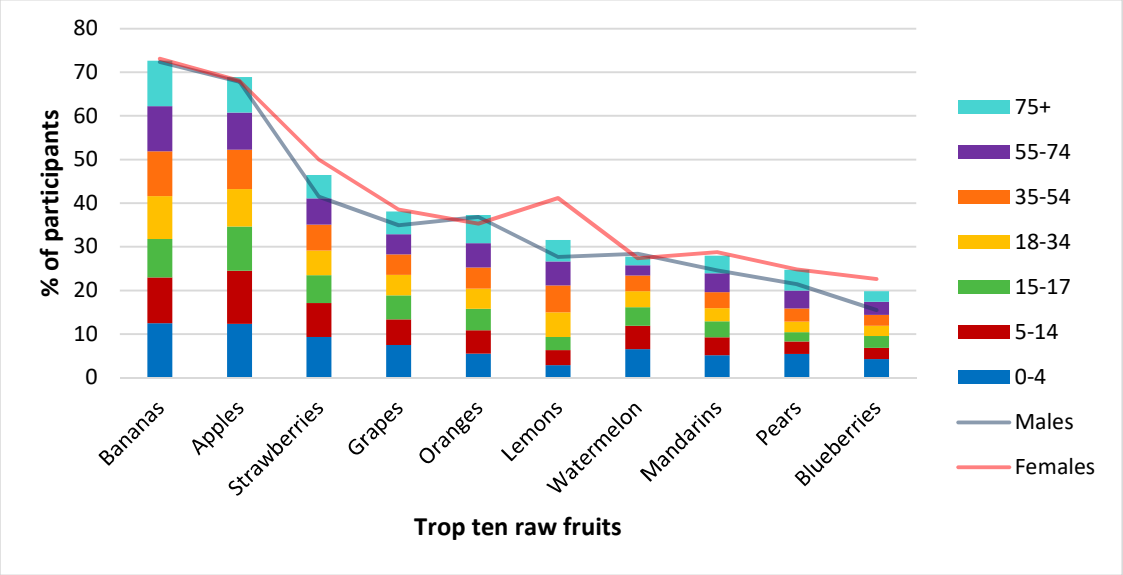
very similar for both sexes, but a higher proportion of females consumed most raw vegetable items. By food item, cucumbers and avocados in particular were consumed by more females. Within age groups this pattern was particularly prominent in the 15-17 year age group, with the majority of raw vegetable food items consumed considerably more by females than males (see Table 8, Appendix 3).

Figure 19: Consumption of the top ten raw vegetables by age group and sex



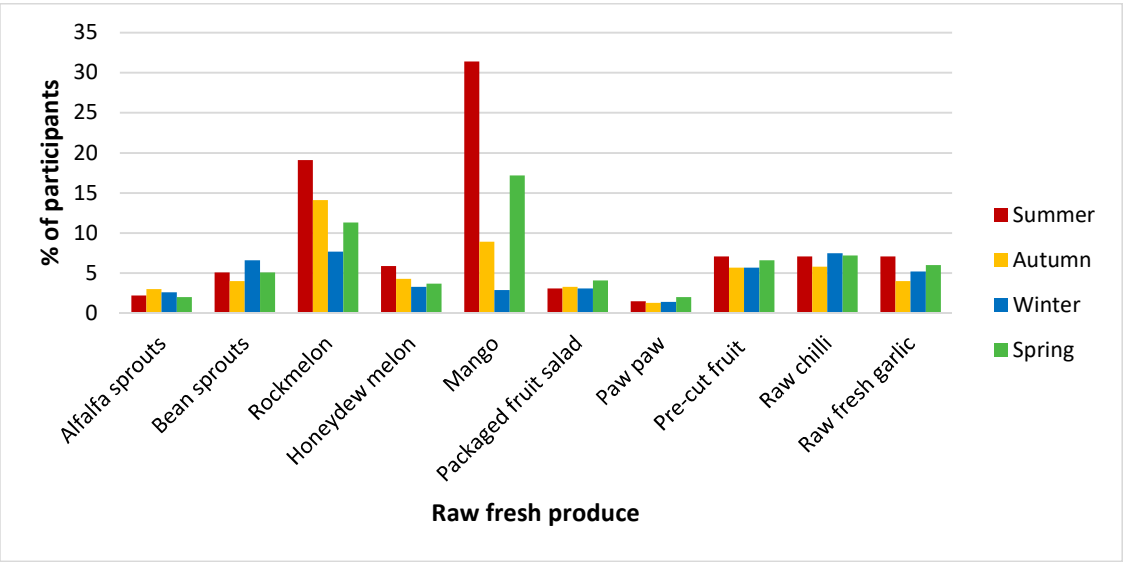
As with raw vegetables, the consumption of raw fruit did not vary substantially by age group, though some trends in consumption can be seen for particular items. For example, lemons were consumed by a much higher proportion of participants in the 18-34, 35-54, and 55-74 year age groups, and were consumed by a substantially greater proportion of females than males (Figure 20). Strawberries were also consumed by a much higher proportion of females than males, and as seen for raw vegetable consumption, a higher proportion of females consumed most raw fruit items to varying degrees.

Figure 20: Consumption of the top ten raw fruits by age group and sex



Consumption of other raw fresh produce items that have previously been associated with *Salmonella* outbreaks in Australia and/or overseas was mostly similar across the seasons, except for mangoes and rockmelons which were consumed by a higher proportion of participants in summer (Figure 21).

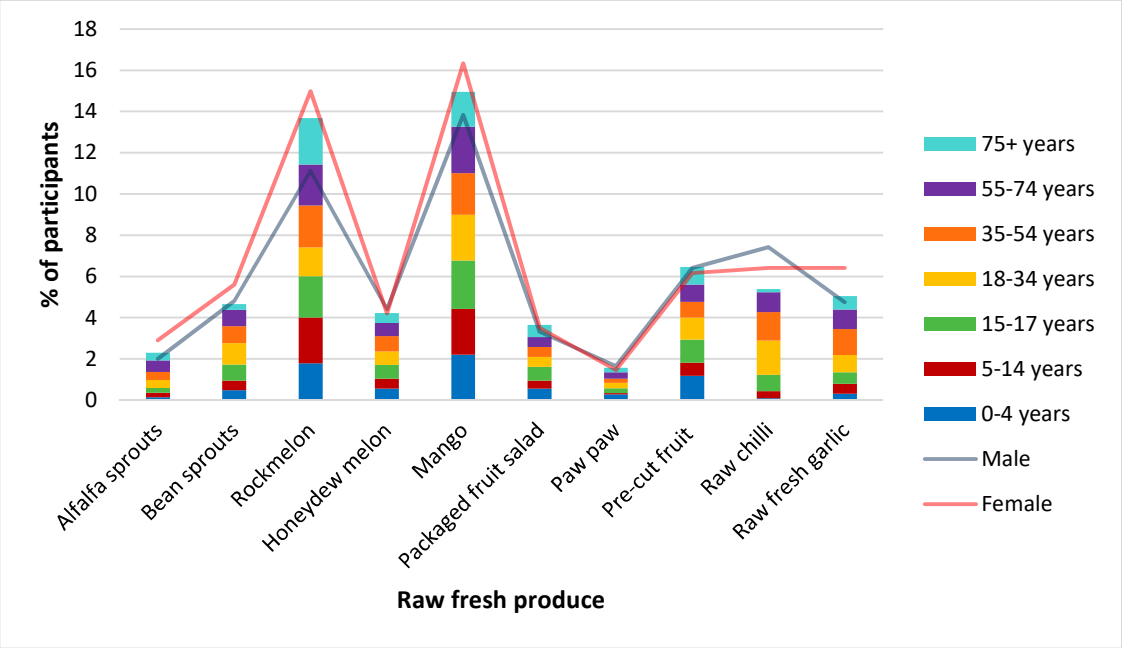
Figure 21: Consumption of raw fresh produce food items previously associated with *Salmonella* outbreaks by season



Most of these fresh produce items were also consumed in similar proportions across all age groups and by both sexes, although raw chilli was consumed by higher proportions of participants in the 18-34 and 35-54 year age groups, and rockmelon and mango were consumed by slightly more females than males (Figure 22). Some notable differences in consumption between the sexes were also observed within age groups: rockmelon was

consumed by 15.7% more females than males in the 15-17 year age group; and mango was consumed by 5.8% more females in the 18-34 year age group (see Table 11, Appendix 3).

Figure 22: Consumption of raw fresh produce food items previously associated with *Salmonella* outbreaks by age group and sex

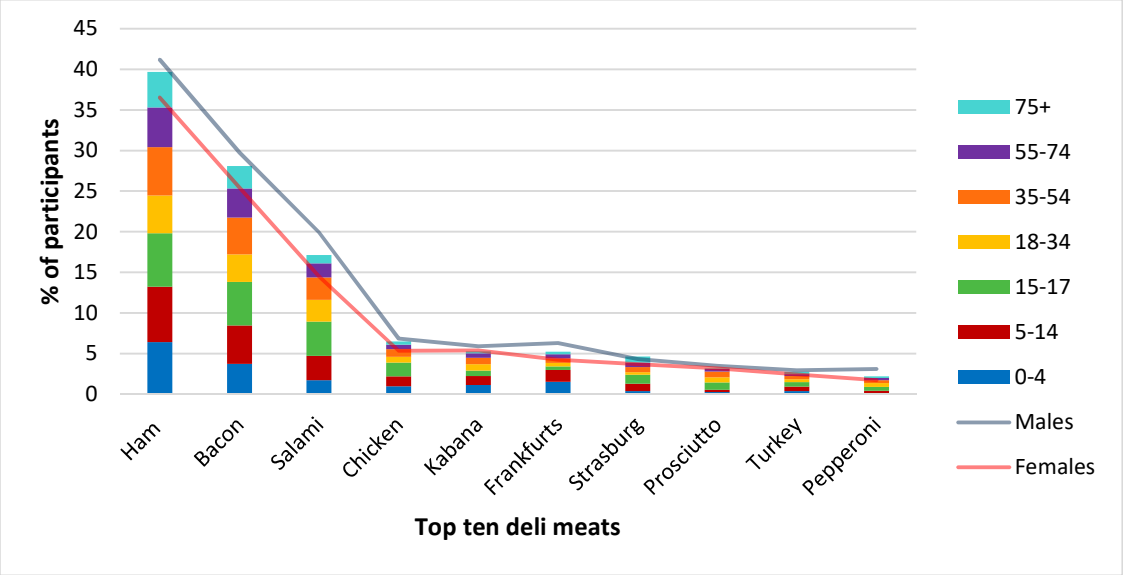


Deli meats

Overall, 44% of VFFS participants consumed at least one type of deli meat in the last seven days from interview. Consumption did not vary by season, but a significantly higher proportion of males consumed deli meats compared to females (47.4% vs 40.7%). Broken down by age group, the difference in consumption of deli meats overall in males and females was only found to be significant for the 18-34 year age group, where 44% of males and only 32% of females consumed deli meats in the last seven days from interview.

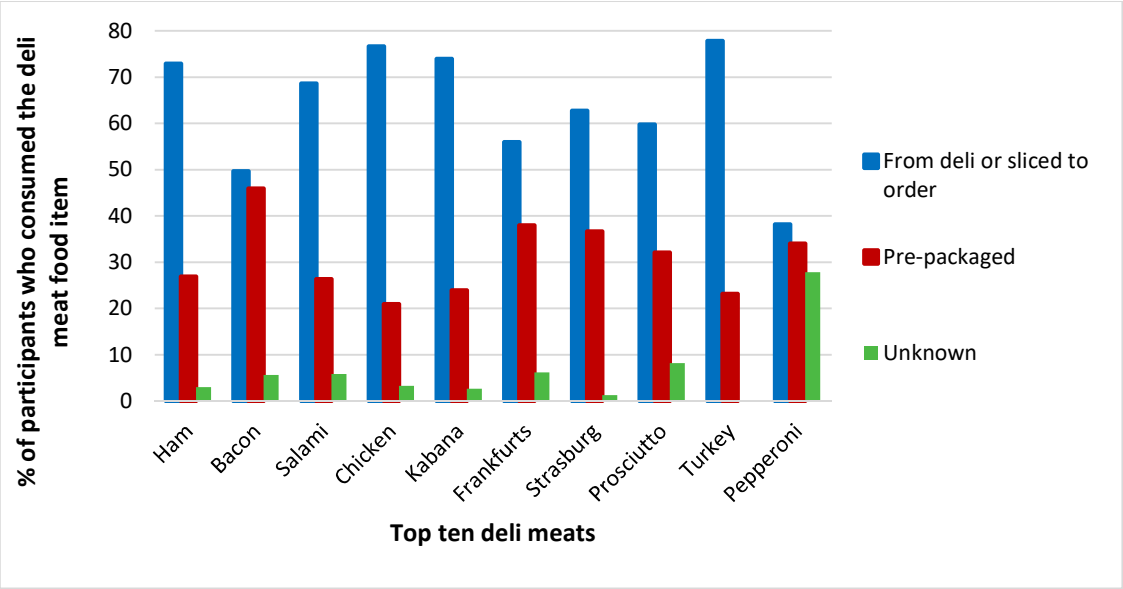
The highest proportion of deli meat consumption overall was in those aged 15-17 years (Figure 23). Ham, bacon, and salami were consistently reported as the top three deli meats consumed in all age groups, with consumption of these meats consistently highest in the 5-14 and 15-17 year age groups. Deli kabana, chicken, and strasburg were also consumed by a higher proportion of participants in these age groups, while deli frankfurts were consumed by a higher proportion of participants in the 0-4 and 5-14 year age groups.

Figure 23: Consumption of the top ten deli meats by age group and sex



A higher proportion of those who consumed deli meats purchased their meats from the deli or sliced to order rather than pre-packaged (Figure 24). This pattern was consistent across age groups and sexes, and applied to the majority of deli meats. Bacon and pepperoni were exceptions, generally purchased in similar proportions pre-packaged and from the deli or sliced to order, though over 25% of those who consumed pepperoni didn't know how it was purchased.

Figure 24: Source of purchase for the top ten deli meats*

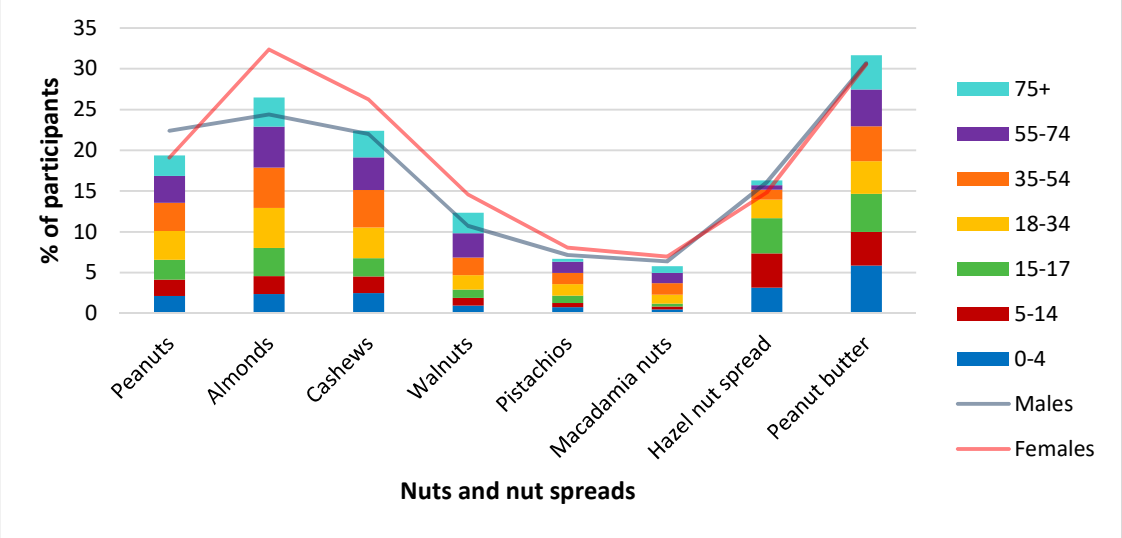


*Proportions may equate to more than 100% as participants who consumed deli meat food items could report multiple sources of purchase

Nuts and nut spreads

Overall, 68% of VFFS participants reported eating nuts or nut spreads in the last seven days from interview. Overall consumption was similar across the seasons and between sexes (67% of males and 69% of females), but there was considerable variation in the consumption of individual nut food items between the sexes (Figure 25). The consumption of cashews, walnuts, and almonds especially was higher in females, but slightly more males than females consumed peanuts. There was also a significant difference in nut consumption across age groups (Figure 25). Those in the 18-34, 35-54, and 55-74 years age groups had the highest consumption of most nuts in fairly similar proportions, while hazelnut spread was consumed by a greater proportion of those in the younger age groups (0-17 years), and participants aged 0-4 years had the highest consumption of peanut butter.

Figure 25: Consumption of nuts and nut spreads by age group and sex

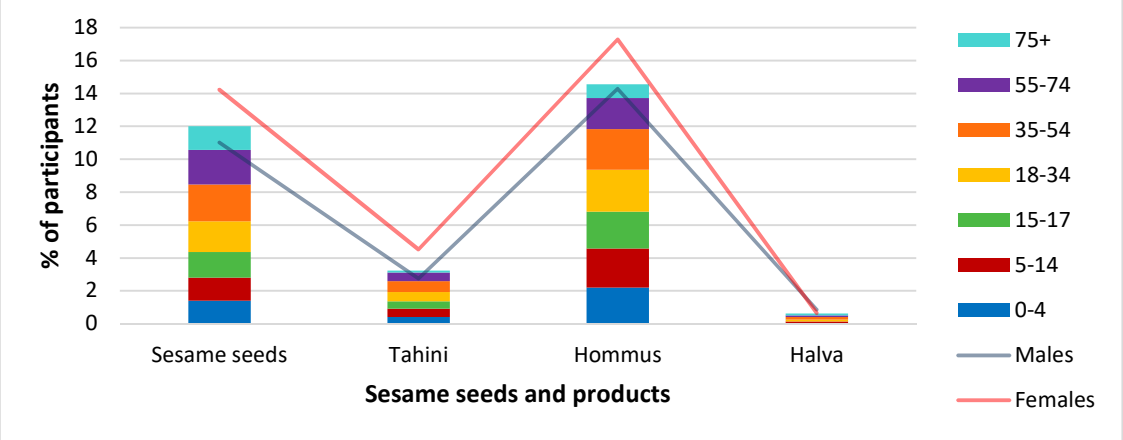


Sesame seeds and sesame seed products

Overall, sesame seeds or sesame seed products were consumed by 26.4% of VFFS participants, with consumption slightly higher in females (29.3% of females and 23.5% males overall). Consumption did not vary substantially by season, but did vary by age group, with a range in consumption proportions of 30.5% in those aged 35-54 years and 16.8% in those aged 75 years or older. When broken down by individual sesame seed food items, hommus and sesame seeds were the most frequently consumed, with a greater proportion of participants in the 35-54 years and 55-74 years age groups consuming sesame seeds, and a greater proportion of participants aged between 18 and

54 years consuming hommus (Figure 26). Both tahini and halva were consumed by a smaller proportion of participants (4.6% consuming tahini, and 1% consuming halva), and both were consumed in the highest proportion by those aged 35-54 years. Sesame seeds, tahini, and hommus were all consumed by a higher proportion of females than males, while halva was consumed in very similar proportions by males and females.

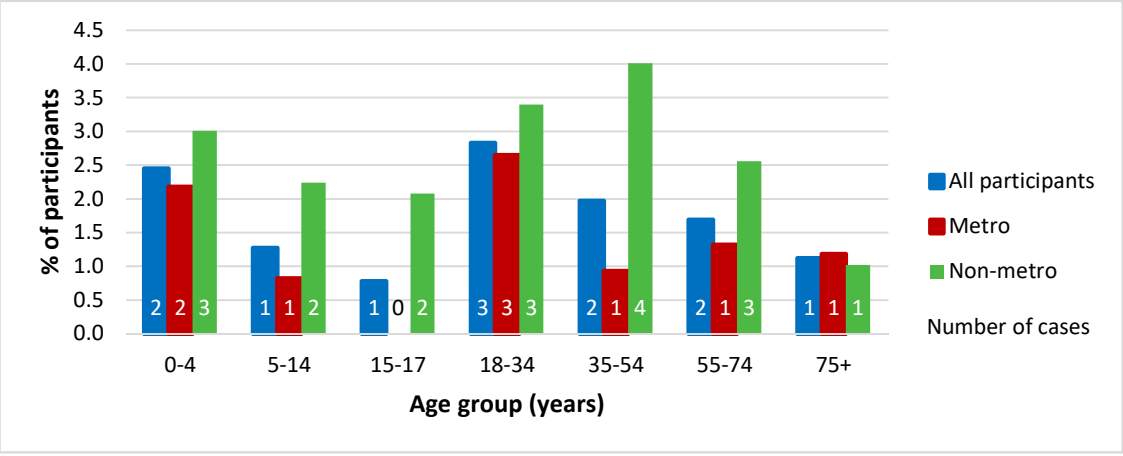
Figure 26: Consumption of sesame seeds and sesame seed products by age group and sex



Unpasteurised milk and cheese

Only 2% of VFFS participants overall consumed unpasteurised milk or cheese in the last 7 days from interview, and consumption was slightly higher in females than males (2.2% vs 1.8%). Consumption did not vary substantially by season, but a significant difference (*P* value = 0.007) was found in consumption between metropolitan and non-metropolitan participants. This difference was more pronounced in some age groups, though consumption remained low in all groups (Figure 27). Unpasteurised milk accounted for the majority of this consumption at 1.7% of participants, while cheese made from unpasteurised milk was consumed by 0.4% of participants.

Figure 27: Consumption proportions of unpasteurised milk and cheese by age group and location



Differences in consumption of food items between the last 7 days from interview and the last 3 days from interview

As mentioned previously, the VFFS collected information on the consumption of food items in both the last seven days from interview and in the last three days from interview for each food item (where relevant). A comparison was made to determine whether there were any large differences in consumption in the last three days compared to the last seven days. Table 1 below shows the food items that had a difference of 10% or greater between the proportion of participants who consumed the item in the last seven days from interview and the proportion of participants that consumed the item in the last three days from interview.

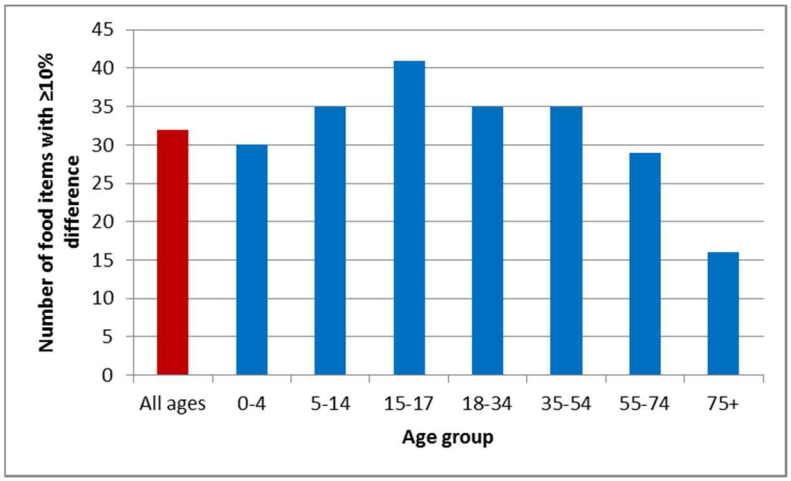
Table 1: Food items with a difference ≥10% between proportion of participants who had consumed the item in the last seven days, and proportion of participants who had consumed the item in the last three days, from the day of interview

Food item	% Ate 7 days	% Ate 3 days	Difference ≥ 10%	Food item	% Ate 7 days	% Ate 3 days	Difference ≥ 10%
Chicken pieces	61.5%	36.7%	**24.8%**	**Parmesan cheese**	32.4%	20.9%	**11.5%**
Other beef	46.5%	23.1%	**23.4%**	**Cucumbers**	52.0%	40.6%	**11.4%**
Beef mince	51.4%	28.2%	**23.1%**	**Deli Ham**	38.9%	27.4%	**11.4%**
Eggs eaten at home	68.9%	50.0%	**19.0%**	**Apples**	67.9%	56.6%	**11.2%**
Broccoli	58.1%	41.4%	**16.6%**	**Celery**	31.5%	20.5%	**11.0%**
Lamb	34.6%	18.4%	**16.3%**	**Tomatoes**	73.2%	62.3%	**10.9%**
Pumpkin	43.5%	27.5%	**16.0%**	**Sweet potatoes**	31.1%	20.3%	**10.8%**
Sausages	33.9%	18.0%	**15.9%**	**Ice cream from a tub**	38.4%	27.7%	**10.7%**
Potatoes	82.2%	68.2%	**14.0%**	**Carrots in a sealed bag**	59.0%	48.3%	**10.7%**
Fresh or frozen fish	28.8%	15.1%	**13.8%**	**Deli Bacon**	27.6%	16.9%	**10.7%**
Strawberries	45.7%	33.2%	**12.5%**	**Other Onions**	50.1%	39.5%	**10.5%**
Green beans	38.5%	26.2%	**12.3%**	**Cauliflower**	32.1%	21.6%	**10.5%**
Zucchini	33.6%	21.4%	**12.2%**	**Other chicken**	20.0%	9.5%	**10.5%**
Red capsicum	43.7%	31.5%	**12.2%**	**Avocado**	41.8%	31.6%	**10.2%**
Chocolate	67.8%	55.8%	**12.0%**	**Whole chicken**	18.5%	8.3%	**10.1%**
Pork	24.8%	13.1%	**11.8%**	**Sauces / chutneys**	55.6%	45.6%	**10.0%**
Mushrooms	37.7%	26.0%	**11.7%**				

Chicken pieces (e.g. breast, thigh, wings) that were purchased raw and prepared and cooked at home had the greatest difference (almost 25%) between seven day and three day consumption. Beef mince and other beef cuts followed closely at 23%, and the consumption proportions of eggs eaten at home were also quite different at 19%. All differences presented in Table 1 were found to be strongly statistically significant (*P* values <0.00001). These differences remained largely consistent over the seasons and

by sex, both in regards to the items that had the most difference in consumption, and with a similar number of items with ≥10% difference. Though mostly similar to the list in Table 1 above, there was some variation in the number of items with a ten per cent or a greater difference across the age groups, and the 75+ year age group was found to have many fewer items with a ten per cent or greater difference (Figure 28).

Figure 28: Number of food items with a difference in consumption of ≥10% between the proportion of participants who had consumed the item in the last seven days, and the proportion of participants who had consumed the item in the last three days, from the day of interview



For all ages combined, food items with a difference of ten per cent or more in consumption between seven and three days from interview represent approximately 13% (n=33) of all the food items included in the VFFS. If this list was expanded to include differences of five per cent or greater across all age groups, the list would represent approximately 38% (n=96) of food items in the survey. This indicates that there is a significant amount of variation in what people consume in a seven day and a three day period, varying slightly by age group.

Case-control analysis

When using all relevant VFFS participant as "controls", the univariate analysis found that cases of *Salmonella* Anatum had statistically significant increased odds for consumption of bagged salad, red onion, and takeaway sandwiches, of which bagged salad had the highest odds ratio (2.87) (Table 2). When included with sex in the multivariate analysis (logistic regression), these increased odds remained statistically significant with no major change to the odds ratios (Table 2).

Table 2: Results of univariate and multivariate analyses for case-control study with all VFFS "controls"

Univariate Analysis			
Food item	**Odds ratio**	**Confidence interval**	***P* value**
Bagged salad	2.87	1.60-5.23	0.0001
Red onion	2.71	1.46-4.94	0.001
Takeaway Sandwich	2.32	1.20-4.35	0.007
Multivariate Analysis			
Food item	**Odds ratio**	**Confidence interval**	***P* value**
Bagged salad	2.6	1.46-4.63	0.001
Red onion	2.45	1.33-4.50	0.004
Takeaway Sandwich	2	1.04-3.9	0.038

The results were similar when the same analyses were applied using only 88 randomly generated VFFS "controls" frequency matched by age as per the original case-case study design. The univariate analysis found that cases of *Salmonella* Anatum had statistically significant increased odds for consumption of bagged salad, red onion, and takeaway sandwiches, but red onions had the highest odds ratio at 3.64 (Table 3). When included with sex in the multivariate analysis (logistic regression), the odds ratios remained statistically significant for bagged salad and red onion, but not for takeaway sandwiches. Red onion had a higher odds ratio and a smaller *P* value than bagged salad, but had a slightly larger confidence interval (Table 3).

Table 3: Results of univariate and multivariate analyses for case-control study with 88 randomly selected, age matched VFFS "controls"

Univariate analysis			
Food item	**Odds ratio**	**Confidence interval**	***P* value**
Bagged Salad	2.5	1.21-5.18	0.008
Red Onion	3.64	1.54-8.85	0.002
Takeaway Sandwich	2.39	1.01-5.7	0.044
Multivariate analysis			
Food item	**Odds ratio**	**Confidence interval**	***P* value**
Bagged Salad	2.44	1.19-4.97	0.014
Red Onion	3.26	1.40-7.56	0.006
Takeaway Salad	1.87	0.78-4.47	0.158

For comparison, the statistically significant results from the univariate analysis and the results of the multivariate analysis from the initial case-case study are provided in Table 4. Takeaway sandwiches were found to be significantly associated with illness in the

univariate analysis, but red onions were not. Red capsicum, lettuce eaten out, and bagged salad products were included with sex in the multivariate analysis, and only the lettuce food items remained significantly associated with illness.

Table 4: Results of univariate and multivariate analyses from the original case-case study

Univariate Analysis			
Food item	**Odds ratio**	**Confidence interval**	***P* value**
Any takeaway food	2.63	1.21-5.68	0.007
Take away sandwiches/rolls/wraps	2.49	1.02-6.21	0.027
Takeaway sandwiches/rolls/wraps with lettuce	3.41	1.25-9.87	0.007
Red capsicum	3.32	1.55-7.14	0.0007
Any lettuce eaten out	3.51	1.65-7.54	0.0003
Any bagged salad products or mixes	3.61	1.72-7.64	0.0002
Multivariate analysis			
Food item	**Odds ratio**	**Confidence interval**	***P* value**
Red capsicum	2.14	0.96-4.77	0.063
Any lettuce eaten out	3.25	1.44-7.35	0.005
Any bagged salad products or mixes	3.19	1.45-7.05	0.004

Discussion

This analysis has demonstrated the utility of VFFS, not just in its intended function as a database of control food frequencies, but in providing valuable information on the food consumption patterns of the Victorian population, giving an indication of who might be at most risk of infection with *Salmonella* and other enteric pathogens from different food sources.

The consumption of major food groups was found to be largely similar by season and sex, although takeaway food consumption was much higher in males. This finding is consistent with other studies examining the consumption of takeaway foods in Australia,[10,11] and is likely related to the well-documented finding that females have more awareness and knowledge of healthy eating and nutrition, which may result in healthier eating habits.[12-14] These studies also found that younger age was associated with a higher frequency of takeaway consumption, with a study by Mohr et al. finding that a negative association was most prominent after the age of 45.[10] This finding is similar to the pattern observed in the VFFS data; a considerably smaller proportion of those in the two oldest age groups consumed takeaway than in the younger age groups,

and this decline began in the 35-54 year age group after a peak in those aged between five and 34 years. Multiple outbreaks of *Salmonella* and other foodborne pathogens have been associated with fast-food or takeaway establishments,[15,16] so it is important to be aware that younger males are at greater risk of infection from these sources, especially as this demographic are acknowledged to be less likely to seek healthcare if unwell and consequently less likely to be identified in an outbreak investigation.[17]

Eggs were consumed by very similar proportions of males and females, and by similar proportions across the age-groups overall. However, as eggs are a high-risk food for *Salmonella* infection, and particularly those consumed semi-cooked or raw and outside the home,[16] it was important look in more detail at their consumption patterns in the population. The VFFS data suggests that consumption of eggs at home is relatively similar across sexes and age groups, and that while a high proportion of people in all age groups consume their eggs with a soft (not fully cooked) consistency, an even higher proportion generally consume them hard (fully cooked). Eggs eaten outside the home, however, were consumed by a much higher proportion of people in the 18-34 year age group, and a lower proportion of participants in this age-group ate their eggs away from home fully cooked. This suggests that those aged 18-34 might be at most risk of *Salmonella* infection from outbreaks in commercial food settings. Consumption of raw eggs either inside or outside the home was low across age all groups.

When considering the above, it should be noted that a clear definition of the difference between a soft and a runny egg was not provided in the VFFS questionnaire script, which may have resulted in some misclassification by participants. It is recommended for future surveys that either precise definitions and examples of the meanings of these terms are included in the questionnaire script, or that clearer alternative terms be employed.

Food items that commonly contain raw or minimally cooked egg were consumed by similar proportions of participants in each age group overall, but individual items were favoured by different age groups. Uncooked cake batter was consumed primarily by those in the 0-4 year age group, and was reported to be known to contain raw eggs by 91% of those who consumed it overall. This finding is concerning as young children in particular are more susceptible to *Salmonella* infection and are more likely to suffer severe illness.[18] Further, raw flour contaminated with *Salmonella* is thought to have

caused a number of outbreaks, including an outbreak in New Zealand in 2008 where consuming raw baking mix was found to be strongly associated with illness.[19] Given the susceptibility of young children to *Salmonella* infection, food-safety messaging surrounding the risks of raw batter consumption in children could be targeted to parents to minimise this practice.

Hollandaise sauce was consumed by a higher proportion of those aged 18-34. It was concerning to find that opposite to cake batter, the majority of those who consumed hollandaise overall did not know whether it contained raw egg. Although this was also the case for tiramisu and chocolate mousse, it is possible for these food items to be made without raw eggs, and this may be why some of those who consumed them did not know whether they contained raw egg. Hollandaise sauce, however, is made primarily with egg yolks and butter, and cannot be cooked to a temperature that would kill *Salmonella* bacteria without curdling and ruining the consistency of the sauce.[20] As hollandaise does go through a low temperature cooking process, however, people may not have been sure whether this process was sufficient to thoroughly cook the eggs.

It is also possible that participants did not know whether the hollandaise contained raw egg because it was consumed outside of the home and not prepared by the participants themselves. Unfortunately information on where these food items were consumed wasn't collected in the VFFS, and it is recommended that should this survey be conducted again these question be included. Sauces containing raw or semi-cooked eggs such as hollandaise and homemade aioli and mayonnaise are frequently cited as the cause of *Salmonella* outbreaks when consumed outside the home, such as in cafés or other commercial food settings.[16] Sauces prepared in these establishments are more likely to be made in larger batches containing more eggs, making them more susceptible to contamination, and if appropriate temperature controls are not in place bacterial growth may occur. As has been previously recommended in chapter two of this volume, consumer advisory notices for foods containing raw or low-cooked eggs on menus might help to increase awareness in the general population of the risks of consuming raw-egg foods, which may help to reduce the incidence of egg-associated outbreaks.

Although similar proportions of males and females reported consuming fruits and vegetables across all age groups, a higher proportion of females standardly consumed individual fresh produce food items than males. This trend was especially pronounced

in the 15-17 year age group. Again, this is likely a result of females generally having a better awareness of healthy eating and nutrition, and subsequently displaying healthier eating habits.[12-14] A similar food frequency survey conducted in Canada also found that females consumed considerably more lemons than males, and the authors hypothesised that this could be due to women adding lemon to water, which could be seen as a 'healthful practice'.[12] Consequently, females, and in particular young adult females, might be at greater risk of infection from outbreaks involving raw fresh produce.

Fresh fruit consumption in the 0-4 year age group was much higher than in other age-groups, indicating that 0-4 year olds may be at greater risk of *Salmonella* infection from fruit-based *Salmonella* outbreaks. However, this trend was not observed in a number of fruits that have previously been associated with *Salmonella* outbreaks, such as rockmelon, paw paw, and mangoes,[21-23] with consumption of these fruits in 0-4 year olds comparable to other age groups.

Differences in consumption between the sexes was also pronounced for some nuts. Males consumed more peanuts than females in the majority of age groups, while females consistently consumed more almonds than males. Interestingly, this pattern was also observed in similar studies from Canada and America .[12,13] Nut-based outbreaks are not common in Australia, but outbreaks involving both peanuts and raw almonds have occurred,[24,25] and it is important to know who might be at most risk of infection in outbreaks associated with different nuts. The VFFS did not collect information on whether nuts were consumed raw or roasted, and as almond-associated outbreaks are often due to raw products,[26] it is recommended that this question be included if the survey is conducted again.

Multiple outbreaks in Australia and overseas have also been associated with contaminated peanut butter.[26] While consumption of peanut butter was generally similar between the sexes, it was consumed by a much higher proportion of children in the 0-4 year age group. This distribution is reflected in reported peanut butter outbreaks, which affected children to a greater extent than other age groups, confirming the disproportionate risk to young children of outbreaks associated with peanut butter.[27-29]

Children from ages 0-17 also had the highest consumption of chicken meat. All age groups primarily consumed chicken pieces purchased raw and cooked at home, but

consumption was highest in those aged 5-14 years. Children aged 0-4 years consumed the highest proportion of frozen chicken strips or nuggets, which is again reflected in outbreaks of *Salmonella* associated with these products both in Australia and overseas in which a high proportion of cases were young children.[30,31] Children aged 0-4 also had a slightly higher consumption of chicken mince compared to older age groups, which was the chicken meat item most frequently consumed pink. As such, depending on the type of product, chicken-associated outbreaks and infections have the potential to disproportionally affect children, so it is important that food safety messages about cooking chicken adequately are reinforced. The consumption of pink chicken meat in the VFFS population was relatively low at 146 participants, but given that Australian studies have found *Salmonella* in close to 35-53% of retail raw chicken samples,[32,33] and *Campylobacter* in 30-90% of samples,[33,34] any consumption of raw or under-cooked chicken meat is concerning.

Outbreaks associated with deli meats might be most likely to affect older children, with consumption of deli meat highest in the 15-17 year age group. Most VFFS participants consumed meats that were loose from the deli or sliced to order, rather than pre-packaged. Deli meats have been implicated in a number of cases and outbreaks of listeriosis especially, and mechanical slicers in retail outlets have been found to be important sources of cross-contamination.[35] Results of a modelling study by Endrikat et al indicated that retail-sliced ready-to-eat meat and poultry products are almost four times more likely to cause listeriosis than pre-packaged products on a per serving basis.[36] As such, it is important to consider the risks posed by sliced-to-order products.

Given the well-established health risks posed by contaminated unpasteurised milk and unpasteurised milk products[37] it was encouraging to find that consumption of these products in the VFFS study population overall was very low. However, it was concerning to find that children in the 0-4 year age group had the second highest consumption proportion between age groups. Children in this age group are not only more susceptible than adults to infection with *Salmonella*,[18] but of particular concern is their susceptibility to Haemolytic Uraemic Syndrome (HUS) following Shiga-toxin producing *Escherichia coli* (STEC) infection.[38] The consumption of raw milk has been associated with multiple cases and outbreaks of STEC in Australia and overseas, which have often developed into HUS in young children.[37] As recently as 2014, a three year old child died from complications

of HUS in Victoria after consuming raw bath milk.[6] As such, consumption of raw milk in the 0-4 year age group in particular should be strongly discouraged.

The higher proportion of unpasteurised milk consumption in non-metropolitan participants may represent people who live on farms consuming milk produced by their own animals. Surveys have indicated that raw milk consumption in farmers is on average much higher than in the general population,[37] and alongside other possible sources of infection farmers are exposed to (e.g. direct contact with farm animals), it is important to be aware that they may be at higher risk of infection from consumption of raw milk.

Sesame seed products represent a more difficult group of products to characterise in regards to consumption risk groups in the VFFS data. Although consumption was slightly higher in the 35-54 year age group, prior outbreaks in these products suggest that risk is highest in cultural groups that tend to have higher consumption of these products.[39,40] Ethnicity data was not collected in the VFFS so this cannot be confirmed in the Victorian population, and as interpreters were not used to interview people who did not speak fluent English, consumption of these items could potentially be underestimated in this data.

Considering this, it is important to note that while the VFFS data provides valuable information on who might be at most risk of exposure to *Salmonella* infection from various food sources, multiple other factors not recorded by the VFFS also contribute to the risk of *Salmonella* infection in an individual, both in terms of what foods they consume and other susceptibilities to infection. The VFSS also only collected food consumption data that is collected by the seven day *Salmonella* food trawler questionnaire, which is not inexhaustible. International foods in particular are underrepresented in the questionnaire, and were an outbreak to occur in such a food group — as it did in a Victorian outbreak associated with imported halva, which resulted in the addition of this food to the questionnaire[39] — the VFFS would be less useful.

Another factor potentially impacting on the usefulness of the VFFS in comparing seven day case food frequencies to VFFS "control" food frequencies is that too much information could be being collected in this period to accurately identify associations. This data analysis found that a number of commonly consumed food items had a difference of 10% or greater between the proportion of people who consumed them in the last seven days and in the last three days. If an outbreak occurred in one of these

commonly consumed food items, for example chicken pieces, the association with illness might be diminished or hidden if large proportions of both cases and "controls" consumed the item. The results of this study indicate that using a three or four day food history instead may lessen the 'noise' collected by the seven day questionnaire and give a more accurate measure of association.

Seven day food trawlers are used primarily because they both represent a week period — which is easier for many people to conceptualise and remember — and because this period is almost certain to capture foods consumed in the salmonellosis incubation period, which is usually between 12 and 36 hours (Oral communication, OzFoodNet Victoria Epidemiologist, September 2017).[3] Considering this, a three day trawler would in the majority of cases be adequate to capture the source of infection, and many published *Salmonella* outbreak investigations report employing three, four, or five day food histories.[19,21,41-44] It is recommended that OzFoodNet review how many instances in which a seven day food history has been necessary, and consider amending their standard procedure to use a shorter timeframe food trawler.

Despite these limitations, this analysis has demonstrated the utility of the VFFS in being able to correctly find an association between illness and the source of a recent outbreak. The VFFS would have been particularly useful in an outbreak such as the *Salmonella* Anatum outbreak, as the similarities in consumption of a food item as common as bagged salad would be difficult to recognise in a case series investigation. However, the analyses did also consistently find red onions to be strongly associated with illness, which the univariate analysis in the original case-case study did not. This shows that although extremely useful in developing hypotheses to narrow down possible sources of infection to develop targeted investigation questionnaires, a database such as the VFFS does not have the strength of an analytical study in collecting representative control data at the approximate time of the outbreak, and indicates that the value of this data will diminish over time as the eating habits in the general population change.

As such, where funding is available, it is recommended that the VFFS is re-administered, and that similar studies are conducted in other states to provide population-specific data and to facilitate food consumption comparisons between states. Where possible, steps should be taken to achieve a more representative dataset, such as employing interpreters to interview people who do not speak fluent English. Although expensive,

databases such as the VFFS contain widely applicable data on food consumption patterns in the population, and facilitate a more timely response to acute public health events, making them valuable tools in the protection of public health.

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Appendices

Appendix 1: OzFoodNet Victoria *Salmonella* cluster investigation questionnaire – full food trawler

Communicable Diseases Case Questionnaire

Salmonellosis

Cluster Questionnaire (Internal Use)

Type: ..... (if known)

Is this a:

CLUSTER INVESTIGATION ☐

OUTBREAK INVESTIGATION
Organism laboratory Confirmed ☐
Organism not laboratory Confirmed ☐

OUTBREAK NAME:

_____

Date:	/ /
Interviewer:	
Person Interviewed (if not case):	
Regional ID No:	
Interpreter used? language:	☐ No ☐ Yes
PROBABLE SOURCE	
DHS USE ONLY	
PHESS Number	
PHESS Updated?	/ /

PRIVACY MESSAGE : The information you provide in this questionnaire is for the purpose of trying to prevent further cases of illness. We do this by trying to find out what is likely to have caused your illness and also by providing you with information to reduce the spread of illness to others. The data collected is kept confidential and identifying information will not be disclosed for any other purpose without your consent. You can access your information by contacting the Department of Health and Human Services. A fact sheet is available ("Privacy Legislation & Notification of Infectious Diseases – Information for Patients") if you would like further information. *Information read?* ☐

SECTION 1: DEMOGRAPHIC DATA

Surname / Family name : _____

Other names: _____

Street Address: _____

Suburb/Town: _____ *Postcode:* _____

Telephone: *H:* ( )_____ *W:* ( )_____ *M:* _____

Date of Birth: / / *or Age:* _____ *Sex:* *Male / Female*

Country of Birth: _____

Language Spoken at Home: _____

Occupation:* _____

Name/Address of Employer or School or Child Care Attended:

Telephone: *Contact Person::*

_____

Date Last attended prior to onset: ___/___/___

High Risk occupational group?* no ☐ yes ☐

Of Aboriginal or Torres Strait Islander Origin?

No ☐
Aboriginal ☐
Torres Strait Islander ☐
Both Aboriginal and Torres Strait Islander ☐

- High risk occupations are food handlers, health care workers, child care workers, children in child care, and residents of institutions (i.e. aged care)

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SECTION 2: TREATING DOCTOR / HOSPITAL

Name of Treating Dr: _____

Address: _____

Telephone: _____ *Facsimile:* _____

Consent given by Doctor to interview: *no* ☐ *yes* ☐ *Date:* / /

Did case present to hospital (e.g. Emergency Dept)? *no* ☐ *yes* ☐ *Name of Hospital:* _____

Was case admitted to hospital? *no* ☐ *yes* ☐ *Date of Admission:* / /

Hospital UR No: _____ *Date of Discharge / Death* / /

SECTION 3: ILLNESS (SUMMARY)

★ Onset date of illness: ___/___/___ ★ Date of Specimen Collection: ___/___/___

Time of onset: ..... am / pm ★ Type of Specimen: Faeces / Blood / Urine / Other

SYMPTOMS	YES/ NO	Date of onset
Fever		
Nausea		
Vomiting		
Abdominal pain		
Lethargy		
Headache		
Other (Specify)		

SYMPTOMS	YES/ NO	Date of onset
Diarrhoea		
Bloody stools		
Watery stools		

Max stools in 24 hours: .....

Duration of diarrhoea:..... days / hours

Total duration of illness: .....days

★History of illness:

★ - indicates both Doctor and case should be asked this question Updated August 2017 2

★ Treatment:

Were you given antibiotics to treat this illness? no ☐ yes ☐ → If yes: What antibiotics? .....

Are you still taking antibiotics? no ☐ yes ☐ What date did you last take the antibiotics? / /

Comments:

SECTION 4: CONTACT DATA

In the two weeks prior to onset of illness, has the case:

- had contact with a family member with a similar illness? ☐ no ☐ yes→ give details in table below:
- had contact with a friend or work/school colleague with a similar illness? ☐ no ☐ yes→give details in table below:

Name	Relationship	Address and phone (if different to case)	Occupation/ childcare / school	Onset date	Faeces culture Y/N

How well did the case recall the information (Sections 2, 3 and 4 – doctors details, illness history and contact details)?
☐ Very Well ☐ Well ☐ Not well ☐ Not at all

SECTION 5: ENVIRONMENTAL RISK FACTORS

In the two weeks prior to onset of illness, did any of the following risk factors apply?

Risk Factor	Applies	Details
Travel **Domestic** (Include all nights away from home – i.e. interstate and local) **International**	no ☐ yes ☐ no ☐ yes ☐	**Places Visited:** .... **Type of Accommodation:** ..... **Date of Departure:** ___/___/___ **Date of Return:** ___/___/___ **Airline:** ..... **Flight Numbers:** .....
Close Contact with farm animals (include petting zoos etc here)	no ☐ yes ☐	**Specify type:** ..... **Specify date(s):** ..... **Location:** .....
Lives on a rural property (i.e. farm, hobby farm)	no ☐ yes ☐	

Has had contact with pets (including fish and reptiles)	no ☐ yes ☐	**Type:** ..... **Has pet been ill?** no ☐ yes ☐ **Type of food?** ..... **Location:** ☐ Home ☐ Other (Specify): .....
Drunk from a private water supply	no ☐ yes ☐	**Specify type:** ..... **Location:** ..... **Is water treated?** no ☐ yes ☐ unknown ☐
Drunk from a public water supply (tap water)?	no ☐ yes ☐	
Drunk any bottled water	no ☐ yes ☐	**Specify brand:** ..... **How often:** .....
Problems with sewage disposal at home?	no ☐ yes ☐	**Specify problem and system type:**
Gardening – contact with potting mix or manure	no ☐ yes ☐	**Type:**
Other known risk factor (i.e. occupational exposure)	no ☐ yes ☐	**Specify:**
Participated in Swimming / Water Sports	no ☐ yes ☐	**Activity:** ..... **Location:** ..... **Date:** .....

How well did the case recall the information (Section 5 - environmental exposures)?
☐ Very Well ☐ Well ☐ Not well ☐ Not at all

SECTION 6: FOOD HISTORY

Three Day Food History - If a detailed 3-day food history cannot be recalled, request information on what is usually eaten at each meal. Collect as much detail as possible for each meal (e.g. for a salad sandwich list all ingredients; for a meal cooked at home list everything eaten) and the number of people that shared each meal.

Day of onset of illness: **Day:** **Date:**		**Time of onset:** **am/pm**
Breakfast:	Brand	Purchased/eaten from
Lunch		
Dinner		
Other snacks and drinks		

Day 1 (day before onset):	Day:	Date:
Breakfast:	Brand	Purchased/eaten from
Lunch		
Dinner		
Other snacks and drinks		
Day 2 (2 days before onset):	**Day:**	**Date:**
Breakfast:	Brand	Purchased/eaten from
Lunch		
Dinner		
Other snacks and drinks		
Day 3 (3 days before onset):	**Day:**	**Date:**
Breakfast:	Brand	Purchased/eaten from
Lunch		
Dinner		
Other snacks and drinks		

Has the case tried any new or different foods recently? ☐ no ☐ yes If yes specify: .....

.....

Has the case been on any specific diets lately? ☐ no ☐ yes If yes specify: .....

.....

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Food History - specific foods

In the week (7 days) prior to illness, did the case eat any of the following foods? (Include all foods consumed during the incubation period and note any commercial brands).

	TYPE / BRAND	PURCHASED FROM
MEAT PRODUCTS PURCHASED RAW		
Chicken pieces ☐ no ☐ yes		
Chicken whole ☐ no ☐ yes		
Chicken mince ☐ no ☐ yes		
Chicken other (eg schnitzel) ☐ no ☐ yes		
Turkey ☐ no ☐ yes		
Duck ☐ no ☐ yes		
Beef mince ☐ no ☐ yes		
Other beef ☐ no ☐ yes		
Lamb ☐ no ☐ yes		
Veal ☐ no ☐ yes		
Pork ☐ no ☐ yes		
Sausages (specify type) ☐ no ☐ yes		
Kebab (specify meat type) ☐ no ☐ yes		
Game meat (spec meat type) ☐ no ☐ yes		
FRESH/FROZEN SEAFOOD (not take-away)		
Fresh/frozen fish ☐ no ☐ yes		
Oysters ☐ no ☐ yes	Circle if eaten: raw or cooked	
Other bi-valve shellfish ☐ no ☐ yes	Circle as appropriate: clams, mussels, scallops, other specify_____	
Other seafood ☐ no ☐ yes	Circle as appropriate: lobster, prawns, bugs, squid/calamari, octopus, crabs, other _____	
Other fish products ☐ no ☐ yes	Circle as appropriate: crab sticks, fish sticks, marinara mix, extender, other_____	
Smoked fish ☐ no ☐ yes	Circle as appropriate: salmon, trout, other_____	
DELICATESSEN PRODUCTS		**BRAND and PURCHASED FROM**
Pre-packed sliced deli meats ☐ no ☐ yes	Circle as appropriate: ham, chicken, turkey, corned beef, pastrami, roast beef, mortadella, strasburg, other_____	
Sliced deli meats(not pre-packed) ☐ no ☐ yes	Circle as appropriate: ham, chicken, turkey, corned beef, pastrami, roast beef, mortadella, strasburg, kabana other_____	
Fermented meats ☐ no ☐ yes	Circle as appropriate: salami, pepperoni, other_____	
Cured meats ☐ no ☐ yes	Circle as appropriate: bacon, prosciutto, speck, capocollo other_____	
Frankfurts ☐ no ☐ yes		
MILK & DAIRY PRODUCTS		**BRAND and PURCHASED FROM**
Pasteurised milk ☐ no ☐ yes	Circle: cows, goats, flavoured, other_____	
unpasteurized milk ☐ no ☐ yes	Circle: cows, goats, other_____	
soy milk ☐ no ☐ yes		

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MILK & DAIRY PRODUCTS (continued)	TYPE / BRAND	PURCHASED FROM
cream ☐ no ☐ yes		
powdered milk ☐ no ☐ yes		
yoghurt ☐ no ☐ yes		
ice cream tub ☐ no ☐ yes		
Other frozen dairy products ☐ no ☐ yes	Circle as appropriate: sorbet, gelati, single ice-creams, yoghurt, soft serve, other _____	
Hard cheese ☐ no ☐ yes	Circle as appropriate: cheddar, parmesan, edam, gouda, other _____	
Soft Cheese ☐ no ☐ yes	Circle as appropriate: cottage, camembert, brie, ricotta, feta, cream cheese, other _____	
Processed Cheese ☐ no ☐ yes	Circle as appropriate: singles, cheese sticks, cheese spread, other _____	
Cheese from unpasteurised milk ☐ no ☐ yes		
EGGS		**BRAND and PURCHASED FROM**
Shell eggs (eaten at home) ☐ no ☐ yes	Hen ☐ Duck ☐ Quail ☐ Are these eggs: free range, barn laid, caged, organic other _____	
If yes, are there any eggs leftover at home from the same carton? ☐ no ☐ yes	If yes, please provide egg stamp number: _____	
Eggs usually cooked ?(usual method of cooking)	Specify _____	**Do you ever eat raw eggs?** ☐ no ☐ yes
Eggs eaten out ☐ no ☐ yes	Usual method of cooking _____	Where _____
Eggs eaten	☐ runny ☐ hard	
other forms ☐ no ☐ yes	Circle as appropriate: powdered, frozen, whites only, yolks only, describe: _____	
FOODS CONTAINING RAW EGGS	**Did the food definitely contain raw egg??**	
Tiramisu ☐ no ☐ yes		
Uncooked Cake batter ☐ no ☐ yes		
Home-made mayonnaise/Aioli ☐ no ☐ yes		
Home-made Caesar dressing ☐ no ☐ yes		
Hollandaise/béarnaise sauce ☐ no ☐ yes		
Chocolate mousse ☐ no ☐ yes		
Home made tartare sauce ☐ no ☐ yes		
Raw egg milkshake/egg nog ☐ no ☐ yes		
Asian pork roll ☐ no ☐ yes		
FOODS CONTAINING LIGHTLY COOKED EGGS	**Describe process - when are eggs added?**	
Home made Custard ☐ no ☐ yes		
Home made ice cream ☐ no ☐ yes		
CONVENIENCE / SNACK FOODS		
Pre-prepared dressed salads ☐ no ☐ yes	Circle as appropriate: coleslaw, potato, pasta, Greek other: _____	
Pre-packed fruit salad ☐ no ☐ yes		

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Pre-packed antipasto products ☐ no ☐ yes | Circle as appropriate: eggplant, dried tomatoes, artichokes other_____ |

	Did you eat this food within the last 7 days?			
	Yes	No	Don't know	Additional information
FRESH PRODUCE				Did you eat it: (can be >1 answer)
celery				☐ raw ☐ cooked ☐ unknown
carrots in a sealed bag				☐ raw ☐ cooked ☐ unknown
loose carrots				☐ raw ☐ cooked ☐ unknown
cucumbers				
broccoli				☐ raw ☐ cooked ☐ unknown
cauliflower				☐ raw ☐ cooked ☐ unknown
green capsicum				☐ raw ☐ cooked ☐ unknown
red capsicum				☐ raw ☐ cooked ☐ unknown
other capsicum				☐ raw ☐ cooked ☐ unknown
chilli				☐ raw ☐ cooked ☐ unknown
asparagus				
fresh corn				
snow peas				☐ raw ☐ cooked ☐ unknown
other fresh peas				☐ raw ☐ cooked ☐ unknown
green beans				☐ raw ☐ cooked ☐ unknown
brussel sprouts				
eggplant				
zucchini				
pumpkin				
onions				☐white ☐brown ☐red ☐unkn ☐ raw ☐ cooked ☐ unknown
salad onions				☐ raw ☐ cooked ☐ unknown
spring onions				☐ raw ☐ cooked ☐ unknown
leeks				
avocado				
tomatoes				☐ raw ☐ cooked ☐ unknown
cabbage				☐ raw ☐ cooked ☐ unknown

potatoes				
	Yes	No	Don't know	Additional information
FRESH PRODUCE				Did you eat it: (can be >1 answer)
sweet potatoes				
alfalfa sprouts				
bean sprouts				
salad mix in sealed bag (e.g baby spinach, rocket)				
loose salad mix				
iceberg lettuce				
other lettuce				
spinach				☐ raw ☐ cooked ☐ unknown
fresh garlic				☐ raw ☐ cooked ☐ unknown
fresh ginger				☐ raw ☐ cooked ☐ unknown
Fresh coriander				☐ raw ☐ cooked ☐ unknown
Fresh Mint (all types)				☐ raw ☐ cooked ☐ unknown
mushrooms				☐ raw ☐ cooked ☐ unknown
beetroot				
turnip				
radishes				
Were any of the vegetables you've eaten known to be organically grown?				
apples				
pears				
peaches				
nectarines				
apricots				
oranges				
mandarins				
grapefuit				
lemons				
limes				

cherries				
	Yes	No	Don't know	Additional information
FRESH PRODUCE				**Did you eat it: (can be >1 answer)**
plums				
grapes				
bananas				
canteloupe (rockmelon)				
honeydew melon				
watermelon				
kiwi fruit				
pineapple				
mango				
paw paw				
blueberries				
raspberries				
strawberries				
pre-cut fruit (purchased already cut into portions/pieces)				
packaged fruit salad				
exotic fruits (dragonfruit, star apple)				
Were any of the fruits you've eaten known to be organically grown?				
homegrown fruits/vegetables				
If yes for homegrown fruits/vegetables, was manure or fertiliser used?				type of manure/fertiliser: (tick all that apply) □cow □sheep □ chicken □ other □ unknown

	TYPE / BRAND	PURCHASED FROM
CONVENIENCE / SNACK FOODS		
coconut desiccated ☐ no ☐ yes		
nuts ☐ no ☐ yes	Circle as appropriate: peanuts, pistachios, almonds, walnuts, cashews, macadamias, other_____	
Nut spreads ☐ no ☐ yes	Circle as appropriate: peanut butter, nutella, other_____	
Sesame seeds/sesame products ☐ no ☐ yes	Circle as appropriate: Tahni, helva, hommous, seeds	
pate ☐ no ☐ yes		
savoury dips ☐ no ☐ yes		
meat paste ☐ no ☐ yes		
Dried fruit ☐ no ☐ yes		
Cakes/cheesecakes ☐ no ☐ yes		
noodles ☐ no ☐ yes	Circle as appropriate: instant, fresh, other_____	
Frozen pre-prepared meals/foods ☐ no ☐ yes	eg weight watcher's, fish fingers, chicken nuggets, pizza,	
refrigerated pre-prepared meals ☐ no ☐ yes	eg pasta sauces, etc	
HERBS AND SPICES		
Spices ☐ no ☐ yes		
Dried herbs ☐ no ☐ yes		
DRESSINGS AND SAUCES		
Salad dressings ☐ no ☐ yes		
Mayonnaise (commercial) ☐ no ☐ yes		
Sauces/chutney ☐ no ☐ yes		
Cooking sauces/marinades ☐ no ☐ yes		
Others ☐ no ☐ yes	specify	
TAKE AWAY FOODS		
BBQ Chicken ☐ no ☐ yes		
Other chicken ☐ no ☐ yes		
Kebabs/souvlaki/Doner ☐ no ☐ yes	Specify type of meat	
Burgers ☐ no ☐ yes	Specify type of meat	
Fish ☐ no ☐ yes		
Salads from a salad bar ☐ no ☐ yes		
Pizza ☐ no ☐ yes		
Sandwiches/rolls/wraps ☐ no ☐ yes	Specify all ingredients:	
Pasta ☐ no ☐ yes		
Bakery products ☐ no ☐ yes	Circle as appropriate: Pies/ pasties/ sausage rolls/quiche other_____	
Asian type foods ☐ no ☐ yes	Circle as appropriate: satays/ spring rolls/ curry puffs/dim sims/ rice paper rolls /sushi other _____	

	TYPE / BRAND	PURCHASED FROM
ETHNIC SPECIALTY FOODS		
Ethnic specific meals ☐ no ☐ yes	Circle: Chinese, Indian, Middle Eastern, Japanese, Italian, other_____	
Tofu ☐ no ☐ yes		
Imported ethnic specialty foods ☐ no ☐ yes		
Other ethnic specialty foods ☐ no ☐ yes		
DRINKS		
Freshly squeezed fruit/veg juice ☐ no ☐ yes	specify: home squeezed, juice bar, grocer Ingredients: _____	
Other fruit/veg juices ☐ no ☐ yes	specify: home squeezed, juice bar, grocer Ingredients: _____	
BABY FOOD PRODUCTS		
Infant formula ☐ no ☐ yes		
Baby food (can, jar etc) ☐ no ☐ yes		

Summary of Food Shopping locations from above table of food trawling history

Food	Name of premises	Address of premises
Meat and smallgoods		
Chicken and other poultry		
Eggs		
Fish and seafood		
Groceries		
Fruit and vegetables (include roadside stalls, markets and home grown)		

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In the week prior to illness did the case eat or buy food from:

	Yes/no/unknown	Name and address of premises	What was eaten and When?
Cafes or restaurants			
Takeaway outlets			
Parties or functions with family or friends			
Festivals or commercial public gatherings (eg fetes, club social events, markets, Moomba etc.)			
Continental deli or specialty grocer (e.g. Asian/mediterranean supermarkets)			
Farmers Markets or other market stalls			

Were any other attendees at these meals/functions ill with gastro symptoms? ☐ no ☐ yes If yes give details:

WHAT DOES THE CASE SUSPECT WAS THE CAUSE OF THEIR ILLNESS? .....

How well did the case recall the information (Section 6 - food history)?
☐ Very Well ☐ Well ☐ Not well ☐ Not at all

SECTION 7: COMMENTS OR CONCLUSIONS

Food samples obtained for the investigation: ☐ no ☐ yes→ give details in the table below:

Type of Food	Date Collected	Result of Analysis

Probable Source of Illness: .....

Comments:

SECTION 8: EDUCATION AND EXCLUSIONS

Hygiene and preventing transmission of Salmonella discussed ☐ No ☐ Yes ☐ N/A

Salmonellosis information provided (brochure) ☐ No ☐ Yes ☐ N/A Date Sent: ___/___/___
☐ Referred to DHS Website (www.health.vic.gov.au/ideas)

Privacy Information requested ☐ No ☐ Yes ☐ N/A Date Sent: ___/___/___

Is case a child in care, resident of an institution or in a high-risk occupation?
☐ *YES → Continue below*
☐ *NO → End of Section 8, Please go to Signature*

☐ **CHILD IN CHILD CARE**

School / Child care exclusion is/was required ☐ No ☐ Yes ☐ N/A
Exclusion(s) discussed with parent / guardian? ☐ No ☐ Yes ☐ N/A

Exclusion from school or child care is required until diarrhoea has ceased.

☐ **CHILD CARE WORKER**

Work exclusion is/was required? ☐ No ☐ Yes ☐ N/A
Exclusion discussed with case? ☐ No ☐ Yes ☐ N/A

It is recommended that the case be excluded from work until diarrhoea has ceased

☐ **FOOD HANDLER**

Work exclusion is/was required? ☐ No ☐ Yes ☐ N/A
Exclusion discussed with case? ☐ No ☐ Yes ☐ N/A

All food handlers with diarrhoea are to be excluded from work until diarrhoea has ceased.

☐ **HEALTH CARE WORKER**

Work exclusion is/was required? ☐ No ☐ Yes ☐ N/A
Exclusion discussed with case? ☐ No ☐ Yes ☐ N/A

It is recommended that the case be excluded from work until diarrhoea has ceased

☐ **RESIDENT OF AN INSTITUTION** (e.g. aged care facility, residential care unit etc)

Isolation is/was required? ☐ No ☐ Yes ☐ N/A
Isolation discussed with primary carer? ☐ No ☐ Yes ☐ N/A

It is recommended that the case be isolated from well residents (as far as practicable) until diarrhoea has ceased.

SIGNATURE

Name of interviewer (please print clearly): _____

Interviewer's Signature: _____ *Date:* ____/____/____

Appendix 2: Consumption tables for major food groups by season, sex, age group, and location

Table 1: Proportion of participants who consumed each food group by seasons, with *P* values for tests of difference of proportions for the consumption of major food groups by season in brackets (statistically significant *P* values ≤0.05 highlighted in orange)

Season	Meat	Deli meat	Fish	Seafood	Vegetables	Fruit	Milk	Cheese	Eggs	Nuts	Takeaway
Sum	93.6% (0.48)	54.0% (0.63)	54.1% (0.1)	24.0% (0.22)	99.0% (0.31)	96.4% (0.8)	86.4% (0.77)	85.4% (0.64)	76.3% (0.74)	56.6% (0.19)	54.9% (0.07)
Aut	94.9% (0.07)	53.9% (0.75)	58.1% (<0.001)	22.3% (0.79)	98.9% (0.22)	96.3% (0.7)	86.2% (0.83)	85.0% (0.76)	77.1% (0.46)	53.5% (0.91)	59.3% (0.86)
Win	92.8% (ref)	53.0% (ref)	50.3% (ref)	21.8% (ref)	99.4% (ref)	96.6% (ref)	85.9% (ref)	84.7% (ref)	75.6% (ref)	53.3% (ref)	58.8% (ref)
Spr	94.7% (0.08)	55.0% (0.34)	57.0% (0.003)	25.0% (0.09)	99.8% (0.16)	95.5% (0.2)	85.8% (0.92)	87.3% (0.08)	76.3% (0.65)	54.4% (0.63)	58.2% (0.82)

Table 2: Consumption of major food groups in the last seven days before interview by sex, with associated *P* values for tests of difference of proportions (statistically significant *P* values ≤0.05 highlighted in orange, and proportions of ≥5% highlighted in yellow and ≥10% different highlighted in green)

Sex	Meat	Deli meats	Fish	Seafood	Vegetables	Fruit	Milk	Cheese	Eggs	Nuts	Takeaway
Males	95.4%	57.4%	53.7%	23.0%	98.9%	95.1%	87.5%	85.7%	75.8%	51.5%	64.1%
Females	92.6%	50.6%	56.1%	23.5%	99.6%	97.3%	84.7%	85.5%	76.9%	57.5%	51.6%
P-value	<0.001	<0.001	0.12	0.76	0.01	<0.001	0.01	0.86	0.45	<0.001	<0.001

Table 3: Proportion of participants who consumed each food group by age group with *P* values for tests of difference of proportions for the consumption of major food groups by age group in brackets (statistically significant *P* values ≤0.05 highlighted in orange, and proportions ≥10% different to the reference age group italicised and bolded)

Age group	Meat	Deli meat	Fish	Seafood	Vegetables	Fruit	Milk	Cheese	Eggs	Nuts	Takeaway
0-4	92.6% (0.78)	56.4% (0.002)	49.0% (0.49)	***13.5%* *(<0.001)***	98.3% (0.03)	98.8% (<0.001)	92.2% (<0.001)	85.8% (0.35)	72.8% (0.29)	***43.9%* *(<0.001)***	***51.7%* *(<0.001)***
5-14	96.5% (<0.001)	***63.2%* *(<0.001)***	50.9% (0.15)	***13.9%* *(<0.001)***	99.6% (0.75)	98.7% (<0.001)	92.1% (<0.001)	86.9% (0.12)	71.6% (0.06)	***37.7%* *(<0.001)***	68.5% (0.87)
15-17	98.4% (0.01)	***68.0%* *(<0.001)***	***34.4%* *(0.005)***	18.8% (0.02)	97.7% (0.02)	95.3% (0.62)	88.3% (0.31)	83.6% (0.84)	66.4% (0.04)	***43.8%* *(<0.001)***	68.0% (0.8)
18-34	92.2% (ref)	47.9% (ref)	47.5% (ref)	28.1% (ref)	99.5% (ref)	94.3% (ref)	84.9% (ref)	84.2% (ref)	75.6% (ref)	62.3% (ref)	69.0% (ref)
35-54	94.0% (0.12)	***58.2%* *(<0.001)***	***59.6%* *(<0.001)***	28.1% (0.96)	99.5% (0.91)	94.8% (0.59)	84.6% (0.85)	86.2% (0.21)	80.5% (0.01)	62.9% (0.78)	58.8% (<0.001)
55-74	94.8% (0.06)	48.9% (0.71)	***70.0%* *(<0.001)***	29.2% (0.62)	99.6% (0.67)	95.7% (0.22)	80.7% (0.03)	87.3% (0.11)	82.6% (0.002)	59.7% (0.34)	***38.6%* *(<0.001)***
75+	93.3% (0.43)	42.5% (0.14)	***70.9%* *(<0.001)***	18.3% (0.001)	98.5% (0.09)	99.3% (<0.001)	79.9% (0.04)	83.6% (0.88)	76.9% (0.64)	***51.1%* *(<0.001)***	***22.0%* *(<0.001)***

Table 4: Consumption of major food groups in the last 7 days before interview by residence location, with associated *P* values for tests of difference of proportions

Residence	Meat	Deli meat	Fish	Seafood	Vegetables	Fruit	Milk	Cheese	Eggs	Nuts	Takeaway
Metro	93.3%	53.2%	56.1%	25.7%	99.2%	96.2%	86.2%	84.7%	76.6%	57.1%	59.0%
Non-metro	95.7%	55.8%	52.1%	17.5%	99.4%	96.1%	85.9%	87.6%	75.6%	48.4%	55.0%
P-value	0.005	0.12	0.02	<0.001	0.49	0.80	0.82	0.02	0.45	<0.001	0.01

Appendix 3: Consumption tables for the top twenty foods consumed by sex, season, and age group

Table 1: Top 20 most commonly consumed foods for VFFS participants overall and by sex

#	All participants	% Ate	Males	% Ate	Females	% Ate
1	**Potatoes**	82.2%	**Pasteurised milk**	82.3%	**Potatoes**	82.4%
2	**Pasteurised milk**	80.6%	**Potatoes**	82.0%	**Pasteurised milk**	78.8%
3	**Tomatoes**	73.2%	**Bananas**	72.3%	**Tomatoes**	75.4%
4	**Bananas**	72.7%	**Tomatoes**	71.1%	**Bananas**	73.0%
5	**Eggs eaten at home**	68.9%	**Eggs eaten at home**	67.8%	**Eggs eaten at home**	70.1%
6	**Apples**	67.9%	**Apples**	67.8%	**Chocolate**	69.2%
7	**Chocolate**	67.8%	**Chocolate**	66.4%	**Apples**	68.0%
8	**Cheddar cheese**	66.9%	**Cheddar cheese**	66.1%	**Cheddar cheese**	67.7%
9	**Butter**	64.1%	**Butter**	63.2%	**Butter**	65.0%
10	**Black pepper**	62.9%	**Chicken pieces**	62.8%	**Black pepper**	63.9%
11	**Chicken pieces**	61.5%	**Black pepper**	61.8%	**Chicken pieces**	60.1%
12	**Carrots in a sealed bag**	59.0%	**Sauces / chutneys**	59.0%	**Carrots in a sealed bag**	59.9%
13	**Broccoli**	58.1%	**Carrots in a sealed bag**	58.0%	**Broccoli**	59.8%
14	**Sauces / chutneys**	55.6%	**Broccoli**	56.3%	**Yogurt**	57.8%
15	**Yogurt**	54.3%	**Beef mince**	53.0%	**Cucumbers**	57.3%
16	**Cucumbers**	52.0%	**Yogurt**	50.7%	**Other Onions**	52.5%
17	**Beef mince**	51.4%	**Other beef**	48.6%	**Sauces / chutneys**	52.3%
18	**Other Onions**	50.1%	**Other Onions**	47.6%	**Strawberries**	49.9%
19	**Other beef**	46.5%	**Cucumbers**	46.7%	**Beef mince**	49.7%
20	**Strawberries**	45.7%	**Red capsicum**	41.7%	**Pumpkin**	48.1%

Table 2: Top 20 most commonly consumed foods for VFFS participants overall and by season

#	All seasons	% Ate	Summer	% Ate	Autumn	% Ate	Winter	% Ate	Spring	% Ate
1	Potatoes	82.2 %	Potatoes	81.3%	Potatoes	82.5%	Potatoes	83.6%	Potatoes	81.4%
2	Pasteur-ised milk	80.6 %	Pasteur-ised milk	80.9%	Pasteur-ised milk	81.3%	Pasteur-ised milk	80.3%	Pasteur-ised milk	79.7%
3	Tomatoes	73.2 %	Tomatoes	78.0%	Tomatoes	73.9%	Bananas	76.0%	Tomatoes	74.1%
4	Bananas	72.7 %	Bananas	69.8%	Bananas	72.4%	Chocolate	69.6%	Bananas	72.5%
5	Eggs eaten at home	68.9 %	Eggs eaten at home	68.5%	Chocolate	70.7%	Apples	69.0%	Cheddar cheese	71.0%
6	Apples	67.9 %	Cheddar cheese	67.3%	Eggs eaten at home	69.6%	Tomatoes	66.9%	Eggs eaten at home	70.8%
7	Chocolate	67.8 %	Chocolate	65.4%	Apples	69.1%	Eggs eaten at home	66.8%	Apples	68.6%
8	Cheddar cheese	66.9 %	Butter	65.3%	Butter	65.5%	Cheddar cheese	65.0%	Chocolate	65.4%
9	Butter	64.1 %	Black pepper	65.2%	Cheddar cheese	64.4%	Broccoli	63.8%	Chicken pieces	65.4%
10	Black pepper	62.9 %	Apples	64.8%	Chicken pieces	61.2%	Black pepper	63.7%	Butter	63.9%
11	Chicken pieces	61.5 %	Cucumber	61.7%	Black pepper	59.8%	Butter	61.7%	Black pepper	62.6%
12	Carrots in a sealed bag	59.0 %	Sauces/ chutneys	59.9%	Carrots in a sealed bag	58.3%	Chicken pieces	61.1%	Broccoli	59.9%
13	Broccoli	58.1 %	Carrots in a sealed bag	59.4%	Broccoli	56.7%	Carrots in a sealed bag	60.1%	Carrots in a sealed bag	58.0%
14	Sauces/ chutneys	55.6 %	Chicken pieces	58.1%	Yogurt	54.3%	Sauces/ chutneys	54.4%	Sauces/ chutneys	55.5%
15	Yogurt	54.3 %	Yogurt	54.7%	Cucumbers	53.4%	Yogurt	53.4%	Yogurt	54.6%
16	Cucumber	52.0 %	Beef mince	51.9%	Sauces/ chutneys	52.6%	Other Onions	52.3%	Cucumber	53.0%
17	Beef mince	51.4 %	Broccoli	51.8%	Beef mince	52.0%	Beef mince	50.1%	Beef mince	51.5%
18	Other Onions	50.1 %	Straw-berries	51.4%	Grapes	51.2%	Mandarins	50.1%	Straw-berries	51.0%
19	Other beef	46.5 %	Other Onions	50.4%	Pumpkin	49.3%	Pumpkin	48.7%	Other Onions	49.4%
20	Straw-berries	45.7 %	Grapes	49.2%	Other Onions	48.0%	Other beef	46.8%	Other beef	47.3%

Table 3: Top 20 most commonly consumed foods for VFFS participants overall and by age group

#	All ages	% Ate	0-4	% Ate	5-14	% Ate	15-17	% Ate	18-34	% Ate	35-54	% Ate	55-74	% Ate	75+	% Ate
1	Potatoes	82.2%	Bananas	87.3%	Pasteurised milk	89.0%	Potatoes	84.4%	Pasteurised milk	77.3%	Potatoes	81.6%	Tomatoes	84.8%	Potatoes	85.1%
2	Pasteurised milk	80.6%	Apples	86.5%	Potatoes	88.5%	Pasteurised milk	79.7%	Potatoes	76.6%	Tomatoes	80.1%	Potatoes	83.1%	Tomatoes	74.3%
3	Tomatoes	73.2%	Pasteurised milk	86.3%	Apples	85.0%	Apples	71.1%	Tomatoes	74.3%	Pasteurised milk	80.0%	Pasteurised milk	76.0%	Pasteurised milk	74.3%
4	Bananas	72.7%	Potatoes	84.3%	Chicken pieces	74.3%	Chocolate	70.3%	Chocolate	69.1%	Eggs eaten at home	72.4%	Eggs eaten at home	74.9%	Bananas	72.8%
5	Eggs eaten at home	68.9%	Yogurt	78.7%	Bananas	73.4%	Butter	69.5%	Bananas	68.9%	Bananas	72.0%	Bananas	72.3%	Eggs eaten at home	69.4%
6	Apples	67.9%	Cheddar cheese	71.3%	Chocolate	73.4%	Broccoli	65.6%	Black pepper	67.1%	Black pepper	72.0%	Black pepper	71.3%	Cheddar cheese	63.1%
7	Chocolate	67.8%	Butter	70.1%	Cheddar cheese	72.2%	Other beef	64.1%	Eggs eaten at home	66.6%	Chocolate	71.9%	Cheddar cheese	68.9%	Chocolate	59.7%
8	Cheddar cheese	66.9%	Eggs eaten at home	68.6%	Carrots in a sealed bag	67.1%	Bananas	61.7%	Butter	63.4%	Cheddar cheese	69.7%	Butter	62.4%	Pumpkin	58.2%
9	Butter	64.1%	Chicken pieces	66.9%	Eggs eaten at home	66.0%	Cheddar cheese	61.7%	Chicken pieces	61.0%	Butter	64.9%	Apples	59.4%	Apples	57.1%
10	Black pepper	62.9%	Carrots in a sealed bag	65.7%	Beef mince	66.0%	Chicken pieces	60.9%	Cheddar cheese	60.7%	Carrots in a sealed bag	63.4%	Chocolate	58.6%	Broccoli	54.1%
11	Chicken pieces	61.5%	Strawberries	65.2%	Sauces/ chutneys	65.7%	Eggs eaten at home	59.4%	Apples	60.0%	Apples	63.3%	Other Onions	57.1%	Black pepper	53.0%
12	Carrots in a sealed bag	59.0%	Chocolate	62.7%	Butter	65.4%	Tomatoes	58.6%	Broccoli	55.5%	Broccoli	59.8%	Chicken pieces	56.2%	Butter	53.0%
13	Broccoli	58.1%	Broccoli	61.8%	Tomatoes	64.3%	Sauces/ chutneys	57.8%	Carrots in a sealed bag	52.2%	Chicken pieces	58.1%	Broccoli	56.0%	Sauces/ chutneys	51.9%
14	Sauces/ chutneys	55.6%	Tomatoes	60.8%	Broccoli	59.8%	Beef mince	56.3%	Cucumbers	51.6%	Cucumbers	56.6%	Carrots in a sealed bag	55.4%	Carrots in a sealed bag	51.1%
15	Yogurt	54.3%	Beef mince	60.5%	Yogurt	58.8%	Ice cream from a tub	56.3%	Sauces/ chutneys	50.8%	Other Onions	56.6%	Sauces/ chutneys	55.4%	Other Onions	49.6%
16	Cucumbers	52.0%	Cucumbers	54.2%	Black pepper	56.3%	Carrots in a sealed bag	55.5%	Yogurt	48.0%	Sauces/ chutneys	55.5%	Yogurt	51.3%	Celery	49.6%
17	Beef mince	51.4%	Sauces/ chutneys	53.7%	Ice cream from a tub	55.0%	Iceberg lettuce	54.7%	Beef mince	46.4%	Yogurt	52.4%	Pumpkin	50.7%	Yogurt	47.8%
18	Other Onions	50.1%	Grapes	52.5%	Strawberries	54.7%	Black pepper	48.4%	Fresh garlic	45.9%	Beef mince	50.8%	Other beef	49.8%	Green beans	47.8%
19	Other beef	46.5%	Sultanas	48.8%	Cucumbers	54.1%	Deli Ham	46.1%	Avocado	45.8%	Red capsicum	49.8%	Cucumbers	48.7%	Other beef	46.6%
20	Straw-berries	45.7%	Sausages	48.5%	Other Onions	51.5%	Yogurt AND Strawberries	44.5%	Commercial bottled water	45.1%	Pumpkin	49.8%	Red capsicum	48.3%	Oranges	45.1%

Note: Yogurt and Strawberries separately were consumed by the same proportion of 15-17 year olds

Appendix 4: Consumption tables for high-risk foods for *Salmonella* infection

Eggs

Table 1: Proportions of egg consumption by location, cooking method, consistency, and age group

Egg consumption	% Ate 0-4	% Ate 5-14	% Ate 15-17	% Ate 18-34	% Ate 35-54	% Ate 55-74	% Ate 75+
Eggs eaten at home	**68.6%**	**66.0%**	**59.4%**	**66.6%**	**72.4%**	**74.9%**	**69.4%**
Boiled	28.9%	26.0%	17.1%	20.6%	27.8%	32.8%	33.9%
Poached	10.7%	15.8%	11.8%	19.6%	23.9%	24.3%	33.9%
Scrambled	38.2%	25.8%	22.4%	27.3%	17.7%	18.8%	16.1%
Fried	28.6%	36.7%	50.0%	39.0%	35.4%	36.3%	25.8%
Omelette	11.1%	9.0%	10.5%	8.0%	8.5%	12.0%	9.1%
Other	8.2%	10.0%	7.9%	8.2%	10.7%	5.3%	6.5%
Consistency Runny	20.0%	23.2%	31.6%	32.0%	28.6%	30.8%	18.3%
Consistency Soft	33.6%	36.9%	36.8%	37.3%	34.4%	42.0%	57.0%
Consistency Hard	55.4%	46.7%	47.4%	36.9%	45.5%	39.0%	29.0%
Eggs eaten away from home	**8.1%**	**5.3%**	**6.3%**	**22.7%**	**18.0%**	**12.9%**	**7.5%**
Boiled	15.2%	10.5%	12.5%	10.9%	17.8%	20.3%	10.0%
Poached	15.2%	15.8%	12.5%	39.3%	33.6%	29.0%	40.0%
Scrambled	45.5%	28.9%	37.5%	21.4%	13.0%	14.5%	10.0%
Fried	15.2%	28.9%	37.5%	26.1%	29.5%	31.9%	20.0%
Omelette	12.1%	7.9%	0.0%	2.7%	4.8%	4.3%	10.0%
Other	3.0%	7.9%	0.0%	6.2%	6.2%	1.4%	15.0%
Consistency Runny	18.2%	21.1%	12.5%	34.2%	28.8%	27.5%	15.0%
Consistency Soft	33.3%	23.7%	50.0%	38.1%	30.8%	29.0%	35.0%
Consistency Hard	45.5%	44.7%	37.5%	29.6%	41.8%	43.5%	50.0%
Any of these eggs consumed raw	**2.0%**	**2.7%**	**1.6%**	**2.7%**	**1.1%**	**0.9%**	**0.7%**

Table 2: Consumption proportions by age group for food items that commonly contain raw eggs

Raw egg containing food items	% Ate 0-4	% Ate 5-14	% Ate 15-17	% Ate 18-34	% Ate 35-54	% Ate 55-74	% Ate 75+
Ate any of the below food items	**21.0%**	**19.0%**	**18.0%**	**21.6%**	**17.0%**	**19.1%**	**20.1%**
Tiramisu	1.0%	1.0%	1.6%	1.4%	1.1%	1.1%	1.5%
Uncooked cake batter	11.0%	7.2%	4.7%	4.2%	3.8%	1.9%	1.5%
Chocolate mousse	2.2%	3.2%	1.6%	4.6%	1.4%	3.2%	2.2%
Raw egg milkshake/egg nog	0.0%	0.6%	1.6%	1.1%	0.4%	0.4%	0.7%
Hollandaise/béarnaise sauce	0.0%	2.1%	3.1%	6.4%	4.6%	3.7%	2.2%
Asian pork roll	0.7%	0.4%	1.6%	2.4%	1.1%	0.9%	0.7%
Homemade ice cream	2.5%	1.4%	1.6%	0.9%	1.4%	1.5%	0.4%
Homemade Caesar salad dressing	1.5%	1.1%	2.3%	1.5%	1.6%	1.7%	4.5%
Homemade mayonnaise/aioli	0.5%	1.5%	3.1%	2.0%	2.6%	3.7%	5.2%
Homemade tartar sauce	0.5%	0.3%	0.0%	0.8%	0.7%	0.6%	0.4%
Homemade custard	4.2%	2.8%	1.6%	1.7%	2.2%	3.9%	4.1%

Table 3: Consumption proportions for all VFFS participants of food items that commonly contain raw eggs, and whether these food items were known to contain raw eggs when consumed

Raw egg containing food items	% Yes	% Unk
Ate any of the below food items	**19.6%**	
Contained raw eggs	***39.4%***	***27.0%***
Tiramisu	1.2%	
Contained raw eggs	*10.4%*	*62.5%*
Uncooked cake batter	4.9%	
Contained raw eggs	*91.2%*	*1.5%*
Chocolate mousse	3.0%	
Contained raw eggs	*17.5%*	*54.2%*
Raw egg milkshake/egg nog	0.7%	
Contained raw eggs	*65.4%*	*11.5%*
Hollandaise/béarnaise sauce	3.9%	
Contained raw eggs	*19.5%*	*57.1%*
Asian pork roll	1.3%	
Contained raw eggs	*2.0%*	*19.6%*
Homemade ice cream	1.3%	
Contained raw eggs	*28.8%*	*13.5%*
Homemade Caesar salad dressing	1.7%	
Contained raw eggs	*16.2%*	*16.2%*
Homemade mayonnaise/aioli	2.4%	
Contained raw eggs	*38.9%*	*13.7%*
Homemade tartar sauce	0.6%	
Contained raw eggs	*21.7%*	*30.4%*
Homemade custard	2.7%	
Contained raw eggs	*20.4%*	*8.3%*

Chicken

Table 4: Consumption proportions by age group for chicken meat food items

Chicken meat food items	%Ate all ages	% Ate 0-4	% Ate 5-14	% Ate 15-17	% Ate 18-34	% Ate 35-54	% Ate 55-74	% Ate 75+
Any chicken meat food item	**78.5%**	**83.1%**	**88.9%**	**80.5%**	**79.2%**	**76.8%**	**71.5%**	**58.2%**
Chicken pieces purchased raw	61.5%	66.9%	74.3%	60.9%	61.0%	58.1%	56.2%	42.2%
Whole chicken purchased raw	18.5%	19.9%	22.1%	28.1%	18.2%	16.9%	17.0%	10.8%
Chicken mince purchased raw	4.6%	5.6%	5.1%	2.3%	5.1%	5.5%	2.2%	2.6%
Other chicken purchased raw	20.0%	18.1%	23.8%	27.3%	20.9%	21.8%	15.0%	9.7%
Deli chicken meat	6.1%	7.1%	8.4%	11.7%	5.2%	6.5%	3.9%	2.6%
Cooked takeaway chicken	12.6%	12.3%	18.4%	20.3%	19.1%	15.9%	10.3%	5.6%
Frozen chicken strips or nuggets	15.6%	24.8%	19.8%	18.0%	12.6%	7.5%	3.9%	4.5%

Table 5: Consumption proportions for all VFFS participants of chicken meat food items and whether they were pink when consumed

Chicken meat food item	% Yes	% Unk
Ate any of below chicken meat	**72.40%**	
Pink when eaten?	***5.1%***	***0.9%***
Chicken pieces purchased raw	61.5%	
Pink when eaten?	*4.0%*	*0.4%*
Whole chicken purchased raw	18.5%	
Pink when eaten?	*3.9%*	*0.9%*
Chicken mince purchased raw	4.6%	
Pink when eaten?	*6.5%*	*1.1%*
Other chicken purchased raw	20.0%	
Pink when eaten?	*3.8%*	*1.1%*

Raw fresh produce

Table 6: Top ten raw vegetables consumed by season

#	% Ate Summer		% Ate Autumn		% Ate Winter		% Ate Spring	
1	**Raw tomatoes**	69.3%	**Raw tomatoes**	59.2%	**Raw tomatoes**	51.8%	**Raw tomatoes**	62.1%
2	**Cucumbers**	61.7%	**Cucumbers**	53.4%	**Avocado**	41.4%	**Cucumbers**	53.0%
3	**Iceberg lettuce**	46.7%	**Avocado**	39.4%	**Cucumbers**	40.0%	**Avocado**	43.2%
4	**Avocado**	43.2%	**Iceberg lettuce**	38.9%	**Iceberg lettuce**	35.6%	**Iceberg lettuce**	41.1%
5	**Raw carrots in a bag**	40.1%	**Raw carrots in a bag**	32.5%	**Raw carrots in a bag**	32.3%	**Raw carrots in a bag**	33.9%
6	**Salad mix in sealed bag**	32.0%	**Salad mix in sealed bag**	23.2%	**Salad mix in sealed bag**	20.8%	**Other lettuce**	27.8%
7	**Raw red capsicum**	28.8%	**Other lettuce**	23.1%	**Raw celery**	20.1%	**Salad mix in sealed bag**	26.6%
8	**Other lettuce**	27.0%	**Raw celery**	21.3%	**Other lettuce**	19.7%	**Raw celery**	21.9%
9	**Raw celery**	23.8%	**Loose salad mix**	20.2%	**Raw spinach**	17.3%	**Raw red capsicum**	21.5%
10	**Raw salad onions**	22.7%	**Raw loose carrots**	19.7%	**Raw loose carrots**	16.6%	**Loose salad mix**	20.8%

Table 7: Top ten raw fruits consumed by season

#	% Ate Summer		% Ate Autumn		% Ate Winter		% Ate Spring	
1	**Bananas**	69.8%	**Bananas**	72.4%	**Bananas**	76.0%	**Bananas**	72.5%
2	**Apples**	64.8%	**Apples**	69.1%	**Apples**	69.0%	**Apples**	68.6%
3	**Strawberries**	51.4%	**Grapes**	51.2%	**Mandarins**	50.1%	**Strawberries**	51.0%
4	**Grapes**	49.2%	**Strawberries**	39.7%	**Oranges**	45.0%	**Oranges**	41.8%
5	**Watermelon**	41.7%	**Lemons**	32.3%	**Strawberries**	40.8%	**Lemons**	34.5%
6	**Lemons**	36.9%	**Oranges**	31.3%	**Lemons**	34.1%	**Watermelon**	28.6%
7	**Nectarines**	36.3%	**Pears**	27.0%	**Pears**	22.4%	**Mandarins**	28.0%
8	**Mango**	31.4%	**Watermelon**	24.7%	**Grapes**	20.7%	**Grapes**	25.9%
9	**Peaches**	28.9%	**Mandarins**	21.7%	**Watermelon**	16.7%	**Pears**	23.5%
10	**Oranges**	26.1%	**Blueberries**	16.5%	**Kiwi fruit**	15.9%	**Blueberries**	22.7%

Table 8: Consumption proportions for top ten raw vegetables by age group and sex, with differences in consumption proportion between sexes of ≥5% highlighted in orange, and ≥10% highlighted in green

#	0-4 years				5-14 years				15-17 years				18-34 years			
	Raw veg	All	M	F	Raw veg	All	M	F	Raw veg	All	M	F	Raw veg	All	M	F
1	Cucumbers	54.20%	52.60%	56.10%	Cucumbers	54.10%	50.60%	59.90%	Iceberg lettuce	54.70%	54.50%	54.90%	Tomatoes	56.70%	54.30%	59.20%
2	Tomatoes	47.50%	48.20%	46.70%	Tomatoes	53.00%	52.40%	54.00%	Tomatoes	48.40%	35.10%	68.60%	Cucumbers	51.60%	46.20%	57.20%
3	Carrots from a bag	42.60%	41.20%	44.40%	Carrots from a bag	44.30%	44.40%	44.10%	Cucumbers	39.10%	33.80%	47.10%	Avocado	45.80%	37.00%	55.00%
4	Avocado	39.20%	41.70%	36.10%	Iceberg lettuce	41.50%	41.20%	41.90%	Avocado	31.30%	24.70%	41.20%	Iceberg lettuce	40.80%	42.20%	39.40%
5	Iceberg lettuce	31.40%	27.60%	36.10%	Avocado	33.10%	29.40%	39.00%	Carrots from a bag	28.10%	22.10%	37.30%	Carrots from a bag	30.90%	27.30%	34.70%
6	loose Carrots	17.90%	17.50%	18.30%	Salad mix in a bag	25.50%	23.70%	28.30%	Loose salad mix	27.30%	24.70%	31.40%	Salad mix in a bag	30.50%	28.60%	32.40%
7	Celery	14.20%	14.00%	14.40%	Red capsicum	23.90%	22.30%	26.50%	Salad mix in a bag	25.00%	20.80%	31.40%	Spinach	25.20%	17.40%	33.30%
8	Salad mix in a bag	14.20%	13.60%	15.00%	Other lettuce	23.80%	22.60%	25.70%	loose Carrots	23.40%	18.20%	31.40%	Other lettuce	25.00%	26.60%	23.40%
9	Red capsicum	13.20%	13.20%	13.30%	loose Carrots	20.30%	20.70%	19.50%	Celery	22.70%	16.90%	31.40%	Loose salad mix	22.30%	21.70%	23.00%
10	Other lettuce	12.50%	11.00%	14.40%	Loose salad mix	17.90%	18.00%	17.60%	Other lettuce	20.30%	18.20%	23.50%	Salad onions	21.30%	21.20%	21.40%

#	35-54 years				55-74 years				75+ years			
	Raw veg	All	M	F	Raw veg	All	M	F	Raw veg	All	M	F
1	Tomatoes	68.90%	66.40%	70.70%	Tomatoes	76.40%	75.80%	76.90%	Tomatoes	66.40%	62.40%	68.90%
2	Cucumbers	56.60%	47.10%	63.00%	Cucumbers	48.70%	43.10%	53.50%	Cucumbers	43.70%	37.60%	47.30%
3	Avocado	46.10%	39.80%	50.40%	Avocado	47.60%	41.50%	52.80%	Iceberg lettuce	36.90%	29.70%	41.30%
4	Iceberg lettuce	43.90%	41.00%	45.90%	Iceberg lettuce	39.10%	39.50%	38.80%	Celery	36.90%	30.70%	40.70%
5	Carrots from a bag	39.10%	35.50%	41.50%	Other lettuce	31.30%	26.60%	35.30%	Avocado	32.10%	22.80%	37.70%
6	Salad mix in a bag	32.30%	26.60%	36.20%	Carrots from a bag	28.10%	25.00%	30.80%	Other lettuce	23.90%	28.70%	21.00%
7	Other lettuce	26.30%	22.90%	28.50%	Red capsicum	27.30%	25.40%	29.00%	Salad onions	23.10%	23.80%	22.80%
8	Celery	25.00%	23.20%	26.20%	Salad onions	26.80%	27.80%	25.90%	Red capsicum	17.90%	17.80%	18.00%
9	Salad onions	23.90%	27.50%	21.50%	Celery	25.50%	25.00%	25.90%	Carrots from a bag	16.00%	16.80%	15.60%
10	Red capsicum	23.80%	21.70%	25.20%	Salad mix in a bag	22.30%	20.60%	23.80%	Spring onions	14.60%	16.80%	13.20%

Table 9: Consumption proportions for top ten raw fruits by age group and sex, with differences in consumption proportion between sexes of ≥5% highlighted in orange, and ≥10% highlighted in green

#	0-4 years				5-14 years				15-17 years				18-34 years			
	Raw fruit	All	M	F	Raw fruit	All	M	F	Raw fruit	All	M	F	Raw fruit	All	M	F
1	Bananas	87.30%	86.80%	87.80%	Apples	85.00%	85.00%	84.90%	Apples	71.10%	68.80%	74.50%	Bananas	68.90%	68.10%	69.80%
2	Apples	86.50%	86.00%	87.20%	Bananas	73.40%	73.10%	73.90%	Bananas	61.70%	62.30%	60.80%	Apples	60.00%	58.50%	61.50%
3	Strawberries	65.20%	63.60%	67.20%	Strawberries	54.70%	51.90%	59.20%	Strawberries	44.50%	40.30%	51.00%	Strawberries	39.80%	31.60%	48.20%
4	Grapes	52.50%	50.40%	55.00%	Grapes	41.20%	39.60%	43.80%	Grapes	38.30%	33.80%	45.10%	Lemons	39.40%	34.00%	45.00%
5	Watermelon	45.60%	52.60%	36.70%	Oranges	37.80%	36.70%	39.70%	Oranges	34.40%	37.70%	29.40%	Grapes	33.20%	30.70%	35.80%
6	Oranges	38.50%	39.90%	36.70%	Watermelon	37.70%	36.90%	39.00%	Watermelon	29.70%	31.20%	27.50%	Oranges	32.30%	33.00%	31.70%
7	Pears	38.20%	36.40%	40.60%	Mandarins	28.40%	24.40%	34.90%	Mandarins	25.80%	22.10%	31.40%	Watermelon	26.00%	23.80%	28.20%
8	Mandarins	36.30%	36.00%	36.70%	Lemons	24.10%	20.50%	29.80%	Lemons	21.10%	18.20%	25.50%	Mandarins	20.90%	18.80%	23.20%
9	Blueberries	30.10%	28.90%	31.70%	Pears	19.80%	19.40%	20.60%	Nectarines	19.50%	16.90%	23.50%	Pineapple	18.30%	18.60%	18.00%
10	Kiwi fruit	20.80%	18.40%	23.90%	Blueberries	17.70%	15.70%	21.00%	Blueberries	18.80%	10.40%	31.40%	Pears	17.00%	14.90%	19.20%

#	35-54 years				55-74 years				75+ years			
	Raw fruit	All	M	F	Raw fruit	All	M	F	Raw fruit	All	M	F
1	Bananas	72.00%	73.10%	71.30%	Bananas	72.30%	70.20%	74.10%	Bananas	72.80%	71.30%	73.70%
2	Apples	63.30%	61.20%	64.70%	Apples	59.40%	55.20%	62.90%	Apples	57.10%	56.40%	57.50%
3	Lemons	42.90%	32.40%	50.00%	Strawberries	42.10%	37.10%	46.50%	Oranges	45.10%	44.60%	45.50%
4	Strawberries	41.60%	36.10%	45.20%	Oranges	39.10%	43.50%	35.30%	Strawberries	37.30%	30.70%	41.30%
5	Oranges	33.70%	33.90%	33.50%	Lemons	39.00%	30.60%	46.20%	Grapes	36.60%	30.70%	40.10%
6	Grapes	32.60%	29.70%	34.50%	Grapes	32.20%	31.00%	33.20%	Lemons	34.30%	23.80%	40.70%
7	Mandarins	25.60%	25.10%	26.00%	Mandarins	30.30%	27.00%	33.20%	Pears	33.20%	31.70%	34.10%
8	Watermelon	25.00%	24.50%	25.40%	Pears	28.70%	29.80%	27.60%	Mandarins	28.40%	27.70%	28.70%
9	Pears	21.20%	16.80%	24.20%	Blueberries	21.20%	17.70%	24.10%	Peaches	20.50%	22.80%	19.20%
10	Kiwi fruit	18.90%	19.00%	18.80%	Nectarines	18.40%	14.50%	21.70%	Kiwi fruit	19.00%	15.80%	21.00%

Table 10: Consumption proportions of raw fresh produce food items previously associated with *Salmonella* outbreaks by season

Raw fresh produce	% Ate Summer	% Ate Autumn	% Ate Winter	% Ate Spring
Alfalfa sprouts	2.2%	3.0%	2.6%	2.0%
Bean sprouts	5.1%	4.0%	6.6%	5.1%
Rockmelon	19.1%	14.1%	7.7%	11.3%
Honeydew melon	5.9%	4.3%	3.3%	3.7%
Mango	31.4%	8.9%	2.9%	17.2%
Packaged fruit salad	3.1%	3.3%	3.1%	4.1%
Paw paw	1.5%	1.3%	1.4%	2.0%
Pre-cut fruit	7.1%	5.7%	5.7%	6.6%
Raw chilli	7.1%	5.8%	7.5%	7.2%
Raw fresh garlic	7.1%	4.0%	5.2%	6.0%

Table 11: Consumption proportions of raw fresh produce food items previously associated with *Salmonella* outbreaks by age group and sex, with differences in consumption proportion between sexes of ≥5% highlighted in orange, and ≥10% highlighted in green

Raw fresh produce	0-4 years			5-14 years			15-17 years			18-34 years			35-54 years			55-74 years			75+ years		
	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F
Alfalfa sprouts	1.0%	0.9%	1.1%	1.5%	1.6%	1.5%	1.6%	1.3%	2.0%	2.7%	1.4%	4.0%	2.8%	3.7%	2.3%	3.9%	3.2%	4.5%	2.6%	2.0%	3.0%
Bean sprouts	3.4%	2.6%	4.4%	3.2%	3.6%	2.6%	5.5%	5.2%	5.9%	7.2%	6.3%	8.3%	5.8%	5.5%	6.0%	5.6%	5.2%	5.9%	1.9%	3.0%	1.2%
Rockmelon	12.5%	12.3%	12.8%	15.5%	14.6%	16.9%	14.1%	7.8%	23.5%	9.7%	7.3%	12.2%	14.3%	11.6%	16.1%	13.9%	11.7%	15.7%	15.7%	14.9%	16.2%
Honeydew melon	3.9%	4.8%	2.8%	3.4%	3.4%	3.3%	4.7%	3.9%	5.9%	4.5%	4.2%	4.9%	5.2%	6.4%	4.3%	4.5%	4.8%	4.2%	3.4%	2.0%	4.2%
Mango	15.4%	15.8%	15.0%	15.6%	14.8%	16.9%	16.4%	15.6%	17.6%	15.5%	12.7%	18.5%	14.2%	13.5%	14.7%	15.7%	14.9%	16.4%	11.9%	8.9%	13.8%
Packaged fruit salad	3.9%	2.6%	5.6%	2.7%	2.7%	2.6%	4.7%	2.6%	7.8%	3.4%	2.6%	4.3%	3.3%	4.6%	2.5%	3.4%	3.2%	3.5%	4.1%	7.9%	1.8%
Paw paw	2.0%	3.1%	0.6%	0.4%	0.5%	0.4%	1.6%	2.6%	0.0%	1.9%	1.7%	2.2%	1.4%	1.5%	1.2%	2.2%	2.4%	2.1%	1.5%	1.0%	1.8%
Pre-cut fruit	8.3%	8.3%	8.3%	4.4%	4.6%	4.0%	7.8%	7.8%	7.8%	7.5%	6.3%	8.8%	5.4%	7.3%	4.1%	5.8%	5.6%	5.9%	6.0%	8.9%	4.2%
Raw chilli	0.7%	0.9%	0.6%	2.4%	2.7%	1.8%	5.5%	6.5%	3.9%	11.6%	13.5%	9.5%	9.7%	10.1%	9.5%	6.7%	6.5%	7.0%	1.1%	2.0%	0.6%
Raw fresh garlic	2.2%	1.8%	2.8%	3.4%	3.0%	4.0%	3.9%	3.9%	3.9%	5.8%	5.7%	5.9%	8.8%	7.3%	9.7%	6.7%	5.2%	8.0%	4.5%	5.0%	4.2%

Table 12: Consumption proportions of the top five deli meats and their source at purchase by age group and consumption ranking

#	Top 5 deli meats	% Ate 0-4	Top 5 deli meats	% Ate 5-14	Top 5 deli meats	% Ate 15-17	Top 5 deli meats	% Ate 18-34	Top 5 deli meats	% Ate 35-54	Top 5 deli meats	% Ate 55-74	Top 5 deli meats	% Ate 75+
	Eaten any deli meat	**45.1%**	**Eaten any deli meat**	**52.9%**	**Eaten any deli meat**	**60.20%**	**Eaten any deli meat**	**38.1%**	**Eaten any deli meat**	**47.8%**	**Eaten any deli meat**	**39.0%**	**Eaten any deli meat**	**35.1%**
1	**Deli Ham**	**45.1%**	**Deli Ham**	**47.5%**	**Deli Ham**	**46.1%**	**Deli Ham**	**32.4%**	**Deli Ham**	**41.8%**	**Deli Ham**	**34.1%**	**Deli Ham**	**30.6%**
	Pre-packaged	*34.8%*	*Pre-packaged*	*22.8%*	*Pre-packaged*	*32.2%*	*Pre-packaged*	*26.7%*	*Pre-packaged*	*29.5%*	*Pre-packaged*	*23.1%*	*Pre-packaged*	*20.7%*
	From deli or sliced to order	*70.7%*	*From deli or sliced to order*	*77.8%*	*From deli or sliced to order*	*72.9%*	*From deli or sliced to order*	*71.1%*	*From deli or sliced to order*	*69.6%*	*From deli or sliced to order*	*73.6%*	*From deli or sliced to order*	*76.8%*
	Unknown	*1.1%*	*Unknown*	*1.2%*	*Unknown*	*0.0%*	*Unknown*	*6.0%*	*Unknown*	*2.1%*	*Unknown*	*4.4%*	*Unknown*	*3.7%*
2	**Deli Bacon**	**26.2%**	**Deli Bacon**	**33.1%**	**Deli Bacon**	**37.5%**	**Deli Bacon**	**23.9%**	**Deli Bacon**	**31.6%**	**Deli Bacon**	**25.3%**	**Deli Bacon**	**19.0%**
	Pre-packaged	*53.3%*	*Pre-packaged*	*46.4%*	*Pre-packaged*	*43.8%*	*Pre-packaged*	*42.6%*	*Pre-packaged*	*49.6%*	*Pre-packaged*	*44.4%*	*Pre-packaged*	*33.3%*
	From deli or sliced to order	*43.9%*	*From deli or sliced to order*	*52.8%*	*From deli or sliced to order*	*54.2%*	*From deli or sliced to order*	*48.1%*	*From deli or sliced to order*	*47.3%*	*From deli or sliced to order*	*50.4%*	*From deli or sliced to order*	*60.8%*
	Unknown	*3.7%*	*Unknown*	*2.1%*	*Unknown*	*2.1%*	*Unknown*	*10.7%*	*Unknown*	*4.3%*	*Unknown*	*6.7%*	*Unknown*	*5.9%*
3	**Deli Salami**	**12.3%**	**Deli Salami**	**20.8%**	**Deli Salami**	**29.7%**	**Deli Salami**	**18.7%**	**Deli Salami**	**19.1%**	**Deli Salami**	**12.4%**	**Deli Salami**	**7.1%**
	Pre-packaged	*32.0%*	*Pre-packaged*	*29.7%*	*Pre-packaged*	*31.6%*	*Pre-packaged*	*25.9%*	*Pre-packaged*	*19.4%*	*Pre-packaged*	*25.8%*	*Pre-packaged*	*36.8%*
	From deli or sliced to order	*62.0%*	*From deli or sliced to order*	*68.9%*	*From deli or sliced to order*	*63.2%*	*From deli or sliced to order*	*69.3%*	*From deli or sliced to order*	*73.5%*	*From deli or sliced to order*	*69.7%*	*From deli or sliced to order*	*42.1%*
	Unknown	*8.0%*	*Unknown*	*2.7%*	*Unknown*	*5.3%*	*Unknown*	*5.2%*	*Unknown*	*7.7%*	*Unknown*	*4.5%*	*Unknown*	*21.1%*
4	**Deli Frankfurts**	**10.8%**	**Deli Frankfurts**	**10.3%**	**Deli Chicken**	**11.7%**	**Deli Kabana**	**5.6%**	**Deli Chicken**	**6.5%**	**Deli Chicken**	**3.9%**	**Deli Strasburg**	**5.2%**
	Pre-packaged	*31.8%*	*Pre-packaged*	*32.9%*	*Pre-packaged*	*13.3%*	*Pre-packaged*	*27.0%*	*Pre-packaged*	*24.5%*	*Pre-packaged*	*23.8%*	*Pre-packaged*	*57.1%*
	From deli or sliced to order	*61.4%*	*From deli or sliced to order*	*61.6%*	*From deli or sliced to order*	*86.7%*	*From deli or sliced to order*	*71.4%*	*From deli or sliced to order*	*75.5%*	*From deli or sliced to order*	*71.4%*	*From deli or sliced to order*	*42.9%*
	Unknown	*6.8%*	*Unknown*	*5.5%*	*Unknown*	*0.0%*	*Unknown*	*1.6%*	*Unknown*	*1.9%*	*Unknown*	*4.8%*	*Unknown*	*0.0%*
5	**Deli Kabana**	**8.1%**	**Deli Chicken**	**8.4%**	**Deli Strasburg**	**7.8%**	**Deli Chicken**	**5.2%**	**Deli Kabana**	**5.4%**	**Deli Kabana**	**3.9%**	**Deli Corned beef**	**5.2%**
	Pre-packaged	*24.2%*	*Pre-packaged*	*11.7%*	*Pre-packaged*	*50.0%*	*Pre-packaged*	*30.5%*	*Pre-packaged*	*18.2%*	*Pre-packaged*	*14.3%*	*Pre-packaged*	*0.0%*
	From deli or sliced to order	*72.7%*	*From deli or sliced to order*	*88.3%*	*From deli or sliced to order*	*40.0%*	*From deli or sliced to order*	*62.7%*	*From deli or sliced to order*	*81.8%*	*From deli or sliced to order*	*85.7%*	*From deli or sliced to order*	*78.6%*
	Unknown	*3.0%*	*Unknown*	*0.0%*	*Unknown*	*10.0%*	*Unknown*	*8.5%*	*Unknown*	*2.3%*	*Unknown*	*0.0%*	*Unknown*	*21.4%*

Table 13: Consumption proportions by age groups for nuts and nut spreads, with differences in consumption proportion between sexes of ≥5% highlighted in orange, and ≥10% highlighted in green

Nut food items	0-4 years			5-14 years			15-17 years			18-34 years			35-54 years			55-74 years			75 years and over		
	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F
Peanut	15.0%	17.5%	11.7%	13.9%	13.4%	14.7%	17.2%	18.2%	15.7%	24.7%	27.8%	21.6%	24.2%	26.0%	22.9%	23.0%	27.0%	19.6%	17.5%	21.8%	15.0%
Almond	16.7%	15.4%	18.3%	15.2%	15.3%	15.1%	24.2%	22.1%	27.5%	34.5%	28.6%	40.5%	34.6%	30.3%	37.6%	35.2%	31.9%	38.1%	25.0%	24.8%	25.1%
Cashew	17.4%	15.8%	19.4%	14.3%	13.2%	16.2%	15.6%	14.3%	17.6%	26.4%	24.8%	28.1%	32.1%	30.6%	33.1%	28.1%	27.8%	28.3%	22.8%	21.8%	23.4%
Walnut	6.6%	6.1%	7.2%	6.8%	7.1%	6.3%	7.0%	5.2%	9.8%	12.4%	10.6%	14.2%	15.2%	12.2%	17.1%	20.8%	19.0%	22.4%	17.5%	16.8%	18.0%
Pistachio	5.1%	5.3%	5.0%	3.8%	2.1%	6.6%	6.3%	6.5%	5.9%	10.0%	10.6%	9.4%	9.5%	8.9%	9.9%	9.6%	10.1%	9.1%	2.6%	2.0%	3.0%
Maca-damia	3.4%	4.4%	2.2%	2.4%	1.8%	3.3%	2.3%	3.9%	0.0%	8.0%	8.5%	7.4%	9.9%	8.6%	10.7%	8.8%	9.7%	8.0%	5.6%	5.0%	6.0%
Hazel nut spread	22.1%	22.4%	21.7%	29.3%	27.6%	32.0%	30.5%	32.5%	27.5%	15.7%	15.3%	16.2%	8.5%	7.6%	9.1%	4.1%	3.6%	4.5%	4.1%	2.0%	5.4%
Peanut butter	40.9%	40.4%	41.7%	28.8%	30.3%	26.5%	32.8%	33.8%	31.4%	27.9%	25.2%	30.8%	30.2%	30.3%	30.2%	31.5%	35.9%	27.6%	29.5%	27.7%	30.5%

Table 14: Consumption proportions by age groups for sesame seeds and sesame seed products, with differences in consumption proportion between sexes of ≥5% highlighted in orange

Sesame food items	0-4 years			5-14 years			15-17 years			18-34 years			35-54 years			55-74 years			75 years and over		
	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F	All	M	F
Sesame seeds	9.8%	11.4%	7.8%	9.8%	9.1%	11.0%	10.9%	10.4%	11.8%	13.1%	12.7%	13.5%	15.7%	11.6%	18.4%	14.6%	10.9%	17.8%	10.1%	7.9%	11.4%
Tahini	2.9%	2.6%	3.3%	3.5%	2.7%	4.8%	3.1%	3.9%	2.0%	4.0%	2.8%	5.2%	4.6%	3.1%	5.6%	3.7%	2.4%	4.9%	0.7%	2.0%	0.0%
Hommus	15.4%	17.1%	13.3%	16.6%	14.6%	19.9%	15.6%	14.3%	17.6%	17.8%	14.9%	20.9%	17.4%	14.7%	19.2%	13.1%	12.9%	13.3%	6.0%	5.0%	6.6%
Halva	0.2%	0.4%	0.0%	0.7%	1.1%	0.0%	0.0%	0.0%	0.0%	0.9%	0.5%	1.3%	1.0%	1.2%	0.8%	0.7%	1.2%	0.3%	0.7%	1.0%	0.6%

Chapter V:

Evaluation of a Surveillance System

Evaluation of the Victorian Hospital Pathogen Surveillance Scheme (VHPSS)

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Preface

Background to project

In the wake of the emergence and subsequent burden of hospital and community acquired methicillin-resistant *Staphylococcus aureus* (MRSA) infections, the Victorian Hospital Pathogen Surveillance Scheme (VHPSS) was established by the Microbiological Diagnostic Unit Public Health Laboratory (MDU PHL) in 1988 to collect information on invasive cases of bacterial and fungal infections and their antimicrobial sensitivities in the Victorian population. This project was conceptualised by MDU PHL director Ben Howden, who identified that a comprehensive evaluation of the VHPSS was overdue and was required to describe the current functioning of the scheme and to identify where, if required, improvements to the scheme could be made.

My role

I was the lead investigator on this project and managed all aspects of the evaluation. I developed a plan for the evaluation; conducted a document review; conducted interviews with VHPSS staff and stakeholders; designed an online questionnaire for contributing laboratories; conducted interviews with non-contributing laboratories; completed data cleaning and analyses; and produced a final report with recommendations for improvements to the scheme. Throughout the evaluation, those who work with the VHPSS provided valuable information, feedback, and advice.

Lessons learnt

Completing this evaluation has greatly increased my skills in surveillance system evaluation, and has given me an appreciation of the multiple and intricate ways different system attributes can interact and inform the performance of each other and the system as a whole. Evaluating a voluntary surveillance system in particular has highlighted for me the importance of stakeholder engagement and ensuring that contributors feel their work is valued and useful, while also ensuring that any improvements to the system do not place further burden on contributors. Developing an online questionnaire for the contributing laboratories also extended my skills in questionnaire development and using online questionnaire platforms.

Public health impact

The key strengths of the VHPSS are that it monitors the incidence and antimicrobial susceptibilities of many pathogens that are not captured by any other surveillance system in Victoria, and that it has consistently collected this information over an almost 30 year period, making it a valuable resource in the surveillance of invasive infections and antimicrobial resistance in Victoria. This evaluation has found that the consistency and completeness of antimicrobial resistance information collected by the system could be improved for greater internal and external comparability, and that improvements to the timeliness of the scheme would allow it to better detect outbreaks within and across different health services.

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- The laboratories who gave their valuable time and opinions in the laboratory questionnaires for this evaluation
- And last but certainly not least, all of the laboratories who contribute to the VHPSS, without whose participation this scheme could not exist

Abstract

Introduction: The Victorian Hospital Pathogen Surveillance Scheme (VHPSS) is a voluntary, laboratory-based surveillance scheme of bacterial and fungal causes of bloodstream infections and meningitis (invasive infections) in the Victorian population. An evaluation of the VHPSS was conducted to describe the current operation of the scheme and to assess its performance against its objectives and key performance indicators.

Methods: This evaluation was guided by the United States' Centres for Disease Control and Prevention (CDC)'s Updated Guidelines for Evaluating Public Health Surveillance Systems. To provide an insight into the data collected by the VHPSS, a summary of data from the 10 year period January 1 2006 to December 31 2015 was conducted in Microsoft Excel and Stata IC 12.1. This data was also analysed to assess system attributes of timeliness and data quality. Evidence regarding the operation, simplicity, stability, flexibility, sensitivity, and representativeness of the scheme was gathered through participant observation, stakeholder interviews, and document review. Evidence of the acceptability of the scheme was gathered from an online questionnaire for contributing laboratories, and email or telephone interviews for non-contributing laboratories. An assessment of the system's usefulness was informed by findings for the above, as was the assessment of the system's performance against its objectives and key performance indicators (KPIs).

Results: This evaluation resulted in a number of recommendations. The system is acceptable to stakeholders overall, but improvements in the efficiency of the notification process for contributing laboratories and the reinstatement of regular feedback (summary reports) to stakeholders would significantly increase the acceptability of the scheme. The scheme is structurally simple, but issues with the antiquated information technology (IT) infrastructure developed for the scheme many years ago increase the complexity of data management and extraction. This IT infrastructure also hampers the ability of the system to be flexible in response to changes in information needs. The timeliness of the system is poor, both in regards to information entering the system and exiting the system, but the quality of the data in the system is generally high. Considering the voluntary nature of the system, it is relatively representative and sensitive, estimated to capture between 80% and 100% of

relevant infections in the Victorian population. Its sensitivity to detect outbreaks, however, is hampered by the poor timeliness of the system.

Discussion: Overall the VHPSS is a useful surveillance system. It collects data on (typically) severe infections and their antimicrobial susceptibilities that are not captured by any other system; it is broadly representative of these infections in the Victorian population; and it has been running consistently for over 29 years, making it a valuable repository of information on pathogen and AMR incidence and trends over time. However, a number of issues exist that hinder the operation of the scheme and limit its usefulness in addressing acute events especially. The system would benefit greatly from investments in new IT infrastructure and additional dedicated staff time, but any changes to the system should only be made after the future purpose and direction of the system is decided.

Introduction

Invasive infections, including bloodstream infections and meningitis, are a major cause of morbidity and mortality worldwide.[1,2] In Australia, septicaemia and meningitis are within the top 15 leading causes of death for children under four years, with septicaemia also a significant cause of death in those aged over 75 years.[3] There is limited published information on the epidemiology of invasive infections, and bloodstream infections (BSIs) in particular, in Australia as a whole[1] due in large part to a dearth of comprehensive BSI surveillance. As will be discussed further in this evaluation, there are multiple surveillance systems and programs in Australia that capture information on invasive infections, but most of these systems only collect certain aspects of this information. For example, a number of systems only collect information on invasive infections believed to have been acquired in a hospital or healthcare facility, thus excluding approximately half of all BSIs that are acquired in the community.[4] Other systems, such as state and national notifiable diseases surveillance systems, only capture information on invasive infections caused by selected pathogens.[5,6]

Despite the significant financial costs to the healthcare system and to human health posed by these infections,[4] there is only one other surveillance system in Australia apart from the system which is the focus of this evaluation that captures all invasive infections caused by any pathogen. However, the Australian Passive antimicrobial resistance (AMR) Surveillance (APAS) system[7] does not collect representative samples of invasive infection data from all Australian states, and as indicated by its title, has a strong focus on antimicrobial resistance. International examples of BSI surveillance in Finland and the United Kingdom show that comprehensive national surveillance of invasive infections is possible, and demonstrate the utility of these systems not only in providing information on trends in invasive infections, but also in the investigation of acute public health events, facilitating faster public health responses and the prevention of further infections.[2]

This situation is reflected in the surveillance of AMR in Australia. Despite being recognised as an urgent global health priority,[8] Australia lacks a coordinated national antimicrobial resistance surveillance system. With limited national oversight, Australia's states and territories each support varied systems for AMR data collection, resulting in a lack of data coordination and comparability. Again, these systems usually only collect

information on AMR in specific pathogens, are often reliant on voluntary contributions, and are predominantly focussed on hospital-acquired infections (HAIs).[9,10] The Australian Passive AMR Surveillance (APAS) system is the only system in Australia that collects AMR data for all clinical samples, allowing it to monitor antimicrobial resistance in all pathogens across all sites of infection. However, apart from Queensland, for which almost all state data is collected, data is only contributed from one or two pathology providers in each other jurisdiction, meaning that the data cannot be fully representative of AMR in Australia.[7]

Internationally, comparable high-income countries such as the United States of America and the United Kingdom have similar issues to Australia, with limited national coordination of state-based and national pathogen-specific surveillance programs.[9,11] Programs such as the Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP) provide a successful model of national coordination of both human and non-human antimicrobial resistance and consumption data, and the European Antimicrobial Resistance Surveillance Network (EARS-Net) demonstrates that this data can be coordinated internationally.[9,12] However, these programs are also limited in their scope, only collecting data for key pathogens, which hampers their ability to monitor resistance incidence and spread in less common pathogens.

Within this context sits the Victorian Hospital Pathogen Surveillance Scheme (VHPSS), which collects information on all invasive infections and their antimicrobial sensitivities in the Victorian population. This evaluation will provide a detailed description of the scheme, assess its functioning and performance against its objectives and key performance indicators, and where required will provide recommendations for its improvement and future development.

The Victorian Hospital Pathogen Surveillance Scheme

The VHPSS is a voluntary, laboratory-based surveillance scheme of bacterial and fungal causes of bloodstream infections and meningitis in the Victorian population.

In the wake of the emergence and subsequent burden of hospital-acquired methicillin-resistant Staphylococcus aureus (MRSA) infections in the 1970s and 80s, the VHPSS was established in 1988 to fill the gap in the available data to define the scale of MRSA as a population health problem in Victoria.[13] The VHPSS was designed to describe the

epidemiological and microbiological characteristics of infections due to bacteria and fungi isolated by diagnostic laboratories from the blood or cerebrospinal fluid (CSF) of patients. Established by the Microbiological Diagnostic Unit Public Health Laboratory (MDU PHL, or MDU for short) under the auspices of the Victorian Health Department's Standing Committee on Infection Control, the VHPSS is not directly funded as an independent surveillance system by the Victorian Department of Health and Human Services (DHHS), but is included in MDU's service agreement with the DHHS and is administered by MDU as an 'in-house' surveillance system. Referred to in this report as the 'VHPSS epidemiologist', the VHPSS is managed and coordinated by an MDU epidemiologist as part of their regular duties. There is also one dedicated part-time data management officer for the VHPSS, who is intermittently supported by a casual data-entry officer.

Aims and objectives of the VHPSS

The stated aim of the VHPSS is to 'monitor the causative agents of bacteraemia and meningitis by collecting, analysing, and disseminating data on isolates from human bloodstream and CSF infections throughout Victoria.[14] The objectives of the VHPSS are:

- To identify trends in the epidemiology of human bacterial/fungal bloodstream and CSF infections acquired in diverse Victorian community and health-care settings;
- To monitor antibiotic resistance in invasive pathogens, as reported by primary diagnostic laboratories, and to actively enhance this surveillance in key pathogens from time to time;
- To classify infections according to length of hospitalisations prior to collection of diagnostic specimen;
- To monitor the emergence of important pathogens and to explore geographic or temporally clustered infection;
- To report possible outbreaks or clusters of a particular organism to the relevant agencies in a timely fashion;
- To enhance existing surveillance of diseases notifiable under the Heath (Infectious Diseases) Regulations;

- To report the current epidemiology of bloodstream and CSF infections to laboratory and clinical staff throughout Victoria in a regular and timely fashion; and
- To operate the scheme according to quality principles, to ensure maximum data quality and timely and accurate reporting.[14]

Key Performance Indicators (KPIs)

The VHPSS Key Performance Indicators (KPIs) were developed to help define and measure the progress of the scheme in achieving its stated aim and objectives. As a scheme reliant on voluntary contributions, not all aspects of the scheme's performance are within the direct control of the scheme, so the KPIs have been split into two groups. KPIs within the direct control of the VHPSS are:

- Input of data: more than 90% of notifications entered into the database within 5 days of receipt at MDUPHL;
- Accuracy and validity of data: no more than 3% errors in total for organism, collection date, gender, date of birth/age, specimen fields in a random sample of 50 VHPSS records;
- Timeliness of response to external data requests: more than 90% within three working days; and
- Output of data: distribution of four quarterly reports covering human isolates (within two months of the end of the specified three month period).

KPIs within the joint control of the VHPSS and contributing laboratories are:

- Timeliness of specimen collection to receipt of notification form/report by VHPSS: 100% within one month of date of isolation; and
- Completeness of case data: the VHPSS is to contain more than 90% of bloodstream and CSF isolates processed by contributing laboratories.[14]

Case definition

The VHPSS case definition for an episode of bacteraemia or meningitis is defined as the first isolation of a species of bacteria/fungi from a blood or CSF specimen from a patient within a 14 day period. Isolations of more than one different species of bacteria/fungi

from the same patient irrespective of time period are counted as separate episodes (if deemed to be clinically significant).[14] Laboratory staff at the primary diagnostic laboratory determine the clinical significance of an isolate on the basis of the microbiological and/or clinical information available to them. If it is decided that the isolate likely represents a contaminant, it should not be reported to the VHPSS.

A surrogate indicator of whether the infection was likely to be health-care associated or community acquired is determined by calculating the duration of hospital stay before collection of the sample (where this information is available). Where a specimen is collected less than three days into hospitalisation, this is thought to suggest a community-acquired infection.

Data collection

Data are sent by participating laboratories (from both the public and private sector) to MDU. Data include patient demographic details (anonymous identifier, age/DOB, sex, and postcode); hospital information (hospital name, unit, and date of admission); and laboratory information (laboratory name, laboratory record number, date of specimen collection, identified bacterium or fungus, and reported antimicrobial susceptibilities). Limited clinical information is also collected if this has been provided to the laboratory. The VHPSS data collection form can be found in chapter Appendix 1.

External data sources

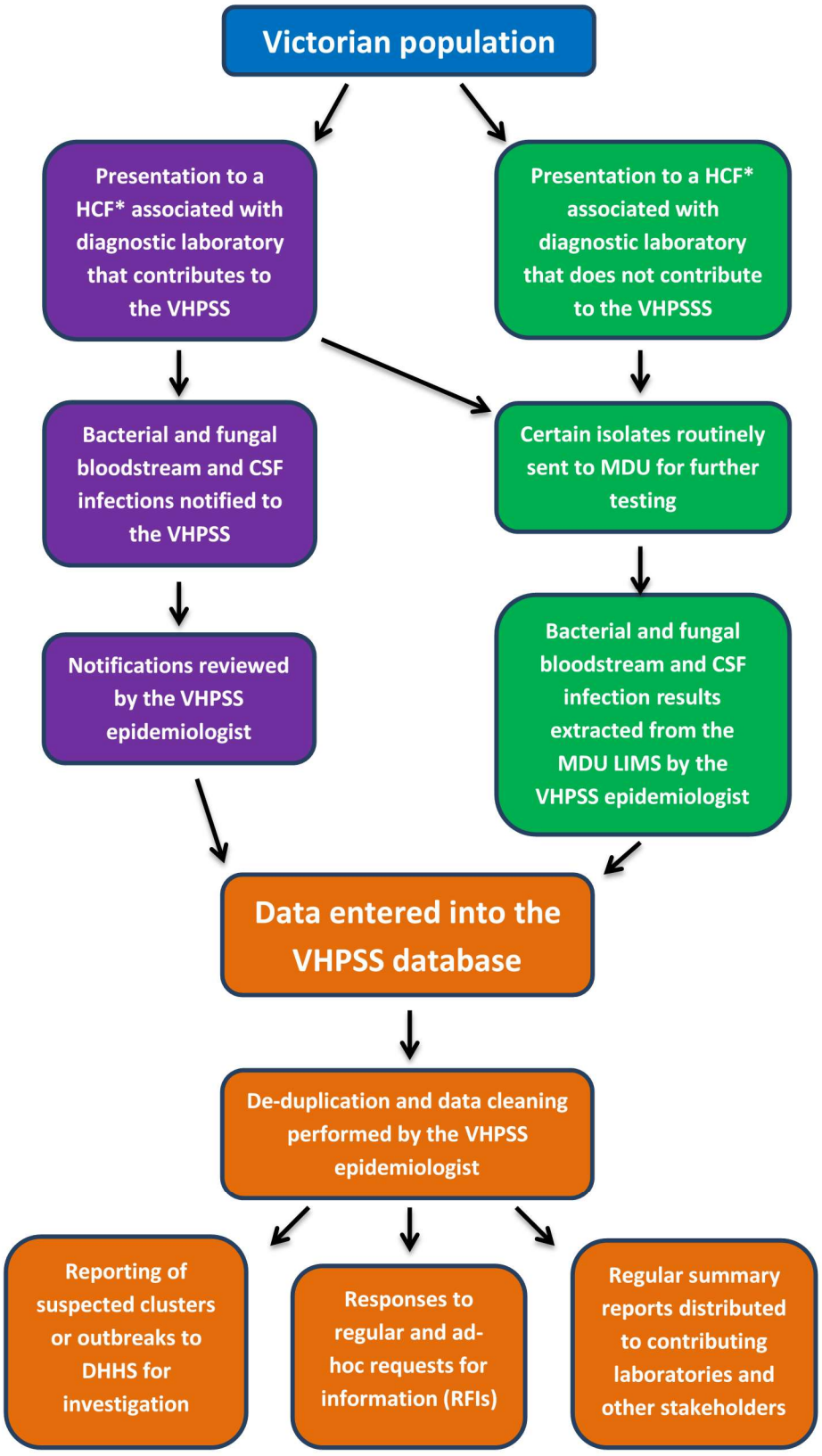
As shown in the VHPSS data flowchart (Figure 1), VHPSS data is collected from both external (contributing laboratories) and internal (MDU) sources. For external data collection from participating laboratories, VHPSS data collection forms pre-labelled with the relevant laboratory code are distributed to participating laboratories. When a bacterial or fungal organism causing a significant infection is isolated from blood or CSF, the VHPSS form is completed and sent to MDU, constituting a 'notification'. While most contributing laboratories use the VHPSS data collection forms to notify, some laboratories have chosen to semi-automate their notifications. For example, some laboratories send direct copies of the same result print-outs that are sent to clinicians; some send a version of their standard result print-out that has been modified specifically for the VHPSS; and some laboratories use the VHPSS form and attach a print-out of a VITEK antimicrobial sensitivity test result slip in lieu of transferring this data to the form.

When an external notification arrives at MDU, the notification is date-stamped and placed in the VHPSS pigeon hole. Notifications are then checked (or 'eyeballed') by the VHPSS epidemiologist for adherence to the case definition and microbiological consistency and validity, including species identification and nomenclature, and antimicrobial testing method sensitivity results. Notifications are then provided to the VHPSS data entry team, who add genus, species, and any applicable typing or comment codes. The data entry team also contact contributing laboratories to clarify any discrepancies and obtain any missing data for key fields. If a notification arrives for an organism that is normally routinely sent to MDU for further typing, and the notifying laboratory has indicated that they have not sent this isolate to MDU (this question is included on the VHPSS data collection form), the VHPSS epidemiologist or data-entry team will contact the laboratory and encourage them to submit the isolate to MDU. Consequently, this process not only ensures data for VHPSS notifications is complete, but also acts as a secondary data completeness check for other MDU and state notification and isolate referral systems.

Internal data sources

Internally, the VHPSS epidemiologist regularly checks the MDU laboratory information management system (LIMS) for results relevant to the VHPSS from isolates that are routinely sent to MDU for confirmation of identification or typing. These isolates can come from both contributing laboratories and from laboratories that do not regularly contribute to the VHPSS, as displayed in the flowchart (Figure 1). The relevant information for these isolates is then taken from the LIMS and entered onto a VHPSS data collection form to create a VHPSS notification.

Figure 1: Flowchart of data entry into and exit from the Victorian Hospital Pathogen Surveillance System (VHPSS)



*HCF = Health Care Facility

Data entry and management

All notifications are entered into the VHPSS database using the VHPSS Data Entry application which has been designed to emulate the VHPSS data collection form. The VHPSS database is a relational Microsoft Access database that is stored on a Microsoft Jet database engine maintained by MDU. Within the database there are four key tables which store information relating to patients, specimens, isolates, and antimicrobial sensitivities, and a series of look-up tables for data, including those pertaining to hospitals, genera, isolate species, and antimicrobials. Data checks are routinely conducted by the data entry team, and data are cleaned on a regular basis (monthly or quarterly) by the VHPSS epidemiologist.

The VHPSS Data Manager application is used to manage updates and changes to all look-up tables used for data entry, and to delete and merge patient records. Data is extracted from the Access database using the VHPSS Report Generator application which can select data by date range, isolate species or genus, and antimicrobials. For each calendar year, all notifications are extracted into a Microsoft Excel format and cleaned and de-duplicated to create an 'historical' reference dataset. The Microsoft Access database is backed up daily by the MDU IT section, and notification forms are stored in hardcopy for one year in filing cabinets and then microfiched.

Data analysis and reporting

After cleaning, data are analysed by the VHPSS epidemiologist and summary reports are distributed to contributing laboratories, the DHHS, and other interested stakeholders on a regular basis. It is stated in the VHPSS policies and procedures manual that reports should be published on a quarterly basis, which is also reflected in the VHPSS Key Performance Indicators (KPIs). These reports include summaries of the number and species of organisms notified to the scheme in the relevant time period (often compared to five year means), and analysis of trends in the epidemiology and antimicrobial sensitivities of organisms of public health importance.

Should the VHPSS epidemiologist identify any apparent clustering of cases, at the analysis or data checking stage, the DHHS Health Protection Branch is notified directly so an investigation can be initiated. The VHPSS also responds to regular and ad-hoc requests for information (RFIs) from the DHHS and from contributing laboratories, which

usually seek to obtain more in-depth information on the incidence and antimicrobial sensitivity trends of a particular organism or species. The details of the RFI are recorded on the RFI Excel spreadsheet for the purpose of summarising how VHPSS data has been used, and for monitoring compliance with the KPIs regarding response time to RFIs.

System evaluation

The policies and procedures manual states that the VHPSS should undergo a major review once in every five years, including reviewing the performance of the scheme against the above KPIs to determine whether the scheme is meeting its aim and objectives. The last major review of the scheme which included consultation with stakeholders (contributing laboratories) was completed in 2003, and reviewed the previous 13 years of VHPSS performance. This review identified a number of issues, particularly in regard to data quality and timeliness of reporting, and resulted in the revision of the VHPSS data collection form; clarification of the case definition; and moving from a flat-file database to the current relational Access database.

Despite the requirement to review the VHPSS every five years as detailed in the manual, a major review of the VHPSS has not been documented in the 13 years since 2003, though intermittent assessments of the performance of the VHPSS against the KPIs have been undertaken. As such, the aim of this evaluation is to conduct a detailed assessment of whether the VHPSS is achieving its aim and objectives, and performing against its KPIs, to determine whether the scheme is functioning efficiently and effectively. The objectives of this evaluation are to:

- Describe the purpose and operation of the scheme
- Provide a summary of the data collected by scheme over the past 10 years
- Assess the performance of the scheme against the Centers for Disease Control's (CDC) key surveillance system attributes, with reference to the scheme's objectives and KPIs
- Assess the overall usefulness (effectiveness) of the scheme, and
- Where required, provide recommendations to improve the functioning of the scheme and increase its usefulness

Methods

Evaluation framework

This evaluation has used the methods outlined in United States' Centres for Disease Control and Prevention (CDC)'s Updated Guidelines for Evaluating Public Health Surveillance Systems.[15] A review of VHPSS documents including the original proposal for the establishment of the scheme, the VHPSS policies and procedures manual, and previous internal and external reviews of the scheme, was conducted alongside stakeholder consultations and data analyses to inform the description of the scheme and assess its performance against its aim, objectives, and KPIs.

The VHPSS was assessed against eight of the nine key surveillance system attributes. Positive predictive value (PPV) was not assessed as this is a measure of the proportion of cases reported to a system that actually have the health-related event under surveillance. As the VHPSS is a laboratory-based system and all notifications represent laboratory-diagnosed cases, PPV is not a useful measure. The potential for a notification to represent a sample contamination rather than a true infection is addressed under the sensitivity attribute.

Data analyses

Historical Microsoft Excel datasets for the years 2006-2015 were used to inform the data summary and to inform the assessment of the system attributes of timeliness and data quality. All analyses and graphs were completed in Microsoft excel.

Notification receipt dates and dates of data entry into the VHPSS are not included in the historical datasets, so for the assessment of timeliness, these dates were exported into Microsoft Excel directly from the VHPSS Microsoft Access database for each year of the 10 year period. Records were then matched by VHPSS ID number using the VLOOKUP command in Microsoft Excel. Any notifications that were not matched during this process were discarded on the assumption that these notifications had been cleaned from the historical data. The total number of days between each date field was then calculated for all matched isolates.

To select the random sample of 50 records from the 2015 historical dataset to asses data accuracy, the RAND command in excel was applied to generate a random number for

each record. The records were then sorted from smallest to largest number, and the first 50 records were selected.

Stakeholder consultations

Informal interviews with the VHPSS epidemiologist, VHPSS data entry officer, and the MDU Information Technology (IT) team were conducted throughout the evaluation to inform the description of the scheme and the assessment of the scheme's performance against the key system attributes. An informal interview with one contributing laboratory was also conducted to gain a more thorough understanding of the notification process from the perspective of the contributor, which assisted in developing the contributing laboratory questionnaire.

The contributing laboratory questionnaire was distributed to the Director and Principal Scientist of each laboratory known to be currently contributing to the VHPSS. It was administered through the online platform SurveyMonkey, and all laboratories could elect to participate in the questionnaire anonymously if desired. The questionnaire aimed to ascertain whether the VHPSS is acceptable and useful to contributing laboratories in regards to their experience of the contribution process, the feedback they receive from the scheme, and their overall perception of the scheme's function. The questionnaire was fully completed by 12 of 22 contributing laboratories, and was partly completed by and additional two. A full list of the questions included in the questionnaire is provided in chapter Appendix 2.

A survey was also sent by email to the Directors of the three major hospital laboratories that do not contribute to the scheme. The email briefly described the scheme and the purpose of the evaluation, and included four questions that attempted to ascertain what knowledge the Director had of the scheme and why their laboratory does not contribute. One laboratory answered the questions via email (though directed one of the questions to the Director of MDU, who answered this question in their capacity as the previous Director of the non-contributing laboratory), one laboratory participated via a telephone interview, and one laboratory did not participate. The text of the original email is included in chapter Appendix 3.

A formal in-person interview was conducted with the Operations Director and a Clinical Researcher from the Victorian Healthcare Associated Infection Surveillance System

(VICNISS) to better understand what data is collected by that system and how it might overlap with the VHPSS.

Results

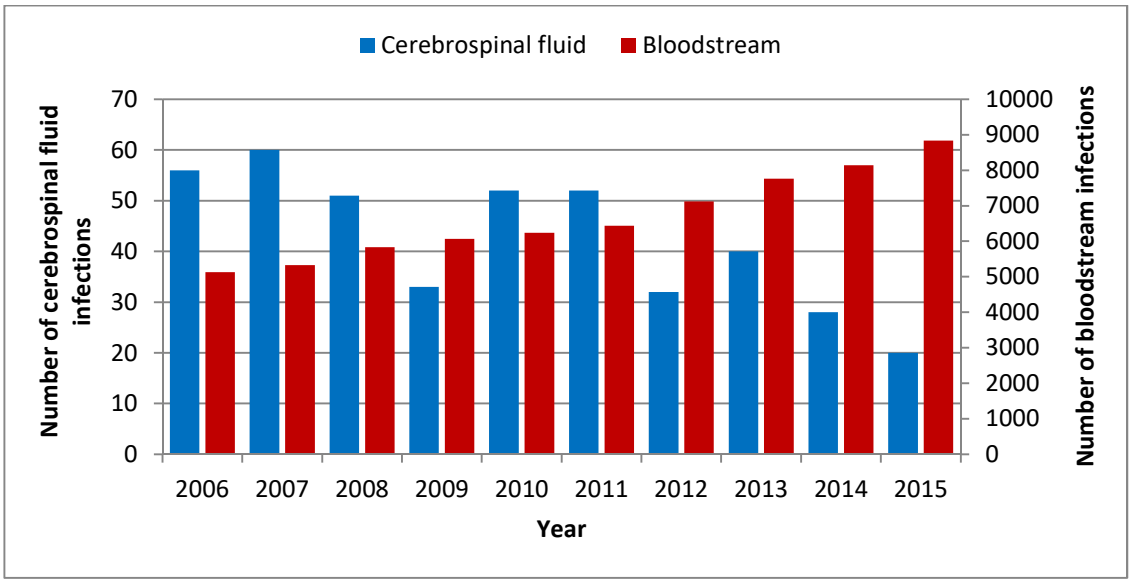
VHPSS data summary: January 2006 to December 2015

To provide an insight into the volume and breadth of data collected by the VHPSS, a data summary for the 10 year period (January 1st 2006 to December 31st 2015) was completed.

Number of notifications

Over this period there were 67,329 bacterial and fungal bloodstream and CSF infections notified to the VHPSS, comprised of 66,905 isolations from blood (99%) and 424 isolations from CSF (1%). Notifications of bloodstream infections increased by a total of 72% over the ten year period, while notifications for CSF infections decreased by a total of 64% (Figure 2). No seasonality was observed in either notifications of bloodstream or CSF infections over the 10 year period.

Figure 2: Number of bloodstream and cerebrospinal fluid infections notified to the VHPSS, 2006 - 2015



Notifications by age and sex

For the combined 10 year period the majority of bloodstream and CSF infections were in males (between 56% and 57% in each year). The age distribution of cases over the 10 year period differed by site of isolation. After a peak in the 0-4 year age group, bloodstream infections rose sharply after cases reached 49 years of age, with those aged

70 years and over accounting for 46% of bloodstream infections (Figure 3). CSF infections were predominantly reported in those aged 0-4 years, accounting for 34% of notifications (Figure 4).

Figure 3: Number of bloodstream infections notified to the VHPSS by sex and age, 2006 – 2015

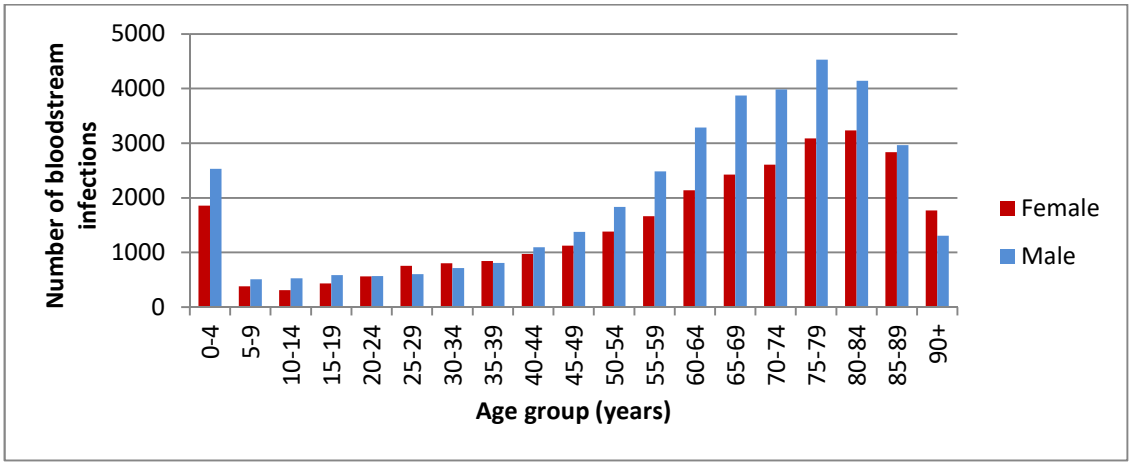
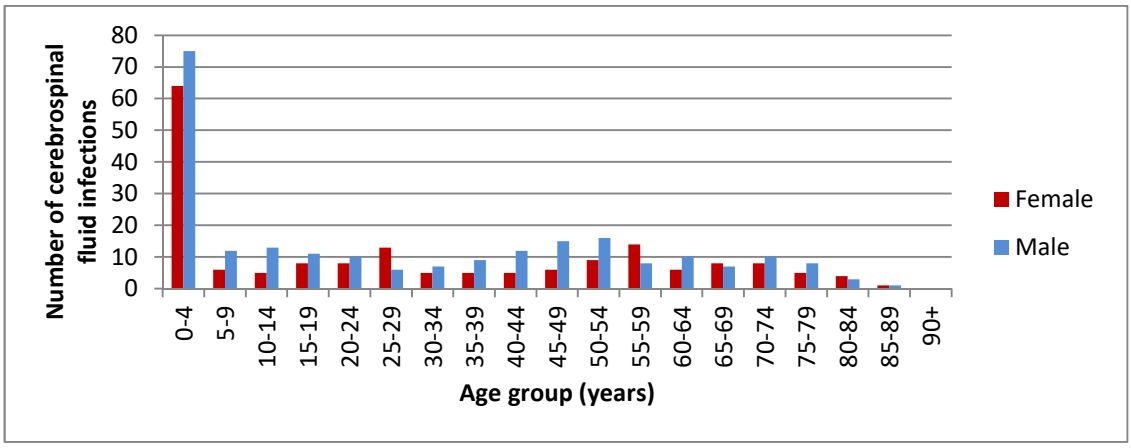


Figure 4: Number of cerebrospinal fluid infections notified to the VHPSS by sex and age, 2006 - 2015



Data contributors

The number of laboratories that contributed data to the VHPSS over the 10 year period varied, ranging between 26 laboratories in 2006 and 19 laboratories in 2013 and 2014. The decrease over time is likely to be due to significant changes in laboratory ownership over the period rather than representing a true decrease in the number of laboratories contributing to the system, as many smaller laboratories were amalgamated into larger organisations. If this did represent a true decrease in the number of laboratories contributing to the system, it would follow that the number of hospitals associated with notifications would also decrease. Instead, the number of hospitals associated with notifications rose steadily over the 10 year period from 103 in 2006 to 135 in 2015. Changes in which hospitals are serviced by contributing laboratories that occur

alongside changes in laboratory ownership are likely to have affected this change in the number of hospitals represented.

Most frequently notified organisms

The ten most commonly notified organisms and their rankings remained relatively stable over the 10 year period (Table 1). The top 3 organisms isolated from blood and CSF remained the same in each year, with *E. coli* accounting for 23-29% of notifications; *S. aureus* for 13-17%; and coagulase-negative *Staphylococcus* for 7-12%. In each year, the most commonly reported coagulase-negative *Staphylococcus* was *S. epidermidis*, followed by *S. capitis*.

Table 1: Ranking of the ten most common organisms isolated from blood and CSF reported to the VHPSS by frequency order, 2006 – 2015

Top 10 organisms	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Escherichia coli	1	1	1	1	1	1	1	1	1	1
Staphylococcus aureus	2	2	2	2	2	2	2	2	2	2
Coagulase negative *Staphylococcus*	3	3	3	3	3	3	3	3	3	3
Streptococcus pneumoniae	4	4	4	4	4	4	4	5	5	5
Klebsiella pneumoniae	5	5	5	5	5	5	5	4	4	4
Enterococcus faecalis	7	6	6	6	6	6	6	6	6	5
Pseudomonas aeruginosa	6	7	7	8	7	7	7	7	7	6
Streptococcus mitis group	8	8	8	9	10	8	8	8	8	7
Enterococcus faecium	-	-	9	7	8	9	9	9	9	8
Enterobacter cloacae	9	9	10	-	9	10	10	-	-	-
Klebsiella oxytoca	10	-	-	10	-	-	-	-	-	-
Group A *Streptococcus*	-	10	-	-	-	-	-	-	-	10
Group B *Streptococcus*	-	-	-	-	-	-	-	10	10	9
Top 10 proportion of isolate notifications	74%	72%	73%	72%	72%	72%	73%	72%	72%	74%

In comparison, organisms associated with CSF infections alone were more varied over the 10 year period, and those notified to the VHPSS more than once in a year are presented in Table 2. *S. pneumoniae* and coagulase-negative *Staphylococcus* infections were consistently notified multiple times in every year, while *N. meningitidis, C. neoformans,* and *S. aureus* were notified at least twice per year in most of the years in the period.

Table 2: Number of CSF isolates notified by organism with more than one notification in a year VHPSS, 2006 – 2015

Organisms isolated from CSF with >1 notification	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Streptococcus pneumoniae	9	6	10	8	12	8	6	5	8	9
Coagulase negative *Staphylococcus*	12	7	7	6	8	9	7	10	9	2
Neisseria meningitidis	9	10	4	3	4	8	4	-	5	-
Cryptococcus neoformans	9	9	6	3	2	4	-	-	-	-
Staphylococcus aureus	-	7	3	5	5	2	-	4	-	2
Haemophilus influenzae	-	6	-	-	3	-	3	5	-	-
Enterococcus faecalis	-	2	2	2	2	5	-	-	-	-
Escherichia coli	4	2	2	-	-	3	-	-	-	-
Listeria monocytogenes	-	-	-	-	-	3	4	2	-	-
Group B *Streptococcus*	3	-	3	-	4	-	-	-	-	-
Streptococcus mitis group	-	-	3	-	3	-	-	-	-	-
Klebsiella oxytoca	-	-	-	-	-	-	2	2	-	-
Enterobacter cloacae	-	2	2	-	-	-	-	-	-	-
Pseudomonas aeruginosa	-	-	-	2	2	-	-	-	-	-
Cryptococcus gattii	-	-	-	-	-	3	-	-	-	-
Candida parapsilosis	-	-	-	-	-	-	-	2	-	-
Enterococcus faecium	-	-	-	-	-	2	-	-	-	-
Proportion of CSF isolate notifications represented	82%	85%	82%	88%	87%	90%	81%	75%	79%	65%

Antimicrobial resistance

Key antimicrobial resistances reported in gram-positive bacteria notified to the VHPSS over the 10 year period are presented in Table 3. The proportion of *S. aureus* isolates that were methicillin-resistant declined by 7% between 2006 and 2010, then remained relatively stable from 2011 to 2015. In all years, the proportion of *S. aureus* isolates that were resistant tended to increase with duration of hospital admission. Resistance was more common among *S. aureus* isolates from specimens collected from patients after seven days of hospitalisation (24-50% resistance) than among those collected between three and seven days hospitalisation (13-20% resistance) and prior to three days hospitalisation (12-17% resistance). Hospital admission dates were supplied for 76-96% of *S. aureus* isolates over the 10 year period.

The proportion of *S. pneumoniae* reported as penicillin non-susceptible also declined over the period from 21% in 2008 to 1% in 2015. After rising to 3% in 2010, vancomycin resistance in *E. faecalis* isolates remained extremely low over the next four years before rising to 1% in 2015. In *E. faecium* isolates, vancomycin resistance increased considerably from 17% to 66% over the 10 year period (Table 3).

Table 3: Prevalence of key antimicrobial resistances of *S. aureus, S. pneumoniae, E. faecalis,* and *E. faecium* reported to the VHPSS, 2006-2015

Year	*Staphylococcus aureus*		*Streptococcus pneumoniae*		*Enterococcus faecalis*		*Enterococcus faecium*	
	Methicillin resistant (%)	Isolates tested (n)	Penicillin non-susceptible (%)	Isolates tested (n)	Vancomycin resistant (%)	Isolates tested (n)	Vancomycin resistant (%)	Isolates tested (n)
2006	22%	880	19%	273	0%	160	17%	59
2007	23%	841	14%	280	2%	176	35%	92
2008	18%	892	21%	348	2%	207	33%	133
2009	16%	943	19%	351	2%	241	48%	152
2010	18%	845	18%	382	3%	227	55%	156
2011	15%	890	12%	377	0%	252	52%	139
2012	15%	1033	15%	344	0%	230	54%	147
2013	18%	1119	12%	370	0%	286	61%	159
2014	14%	1177	13%	348	0%	171	59%	87
2015	15%	1270	1%	325	1%	330	66%	215

Key antimicrobial resistances in the frequently reported gram-negative bacteria *E. coli* and *K. pneumoniae* notified to the VHPSS over the ten year period are presented in Table 4. Amoxicillin resistance in both organisms remained relatively stable over the 10 year period, with 49-53% of tested *E.coli* isolates, and 97-100% of tested *K. pneumoniae* isolates, reported as resistant in each year. The proportion of tested isolates resistant to at least one of the 3rd generation cephalosporins (3GCs) ceftazidime, cefotaxime, or ceftriaxone increased by 10% in *E. coli* and 4% in *K. pneumoniae* over the 10 year period. However, there was a gradual decease in the proportion of *E. coli* isolates that were resistant to two or all three of these 3GCs, and a gradual decrease in the proportion of *K. pneumoniae* isolates resistant to all three 3GCs.

Ciprofloxacin resistance increased by 9% in tested *E. coli* isolates over the 10 year period. An increase was also observed in tested *K. pneumoniae* isolates, but this increase peaked in 2011 and 2012 before beginning to decrease in the following years. This pattern was also observed in gentamicin resistant *K. pneumoniae* isolates, with a small increase in resistance in 2010/2011 then a return to previous levels in the following years. Gentamicin resistance in tested *E. coli* isolates increased by 4% over the 10 year period, peaking and continuing at 7% from 2012 onward. Notifications of E.coli isolates with resistance to a carbapenem antibiotic became less frequent over the 10 year period, with one or two cases in every year from 2006 – 2010, and only three cases over the next five year period. Carbapenem resistance in *K. pneumoniae* isolates peaked in 2012 with five cases, before declining in the following three years.

Table 4: Prevalence of key antimicrobial resistances of *E. coli* and *K. pneumoniae* reported to the VHPSS, 2006-2015

	% Amoxicillin resistant	% result reported	% resistant to at least one 3GC*	% result reported	% resistant to two 3GCs	% resistant to three 3GCs	% Ciprofloxacin resistant	% result reported	% Gentamicin resistant	% result reported	Carbapenem resistances notified	% result reported	Cases resistant to 3 or more of these antimicrobial families (MDR)
E. coli													
2006	49%	99%	3%	91%	69%	11%	3%	90%	3%	98%	1 Meropenem	79%	25 (2%)
2007	49%	99%	4%	87%	72%	10%	5%	91%	4%	98%	1 Meropenem	76%	32 (3%)
2008	48%	99%	4%	86%	60%	15%	6%	95%	4%	99%	1 Imipenem	77%	45 (3%)
2009	49%	99%	5%	83%	79%	6%	7%	95%	5%	99%	1 Meropenem	76%	75 (5%)
2010	46%	100%	5%	84%	75%	13%	5%	97%	4%	99%	2 Meropenem	73%	56 (4%)
2011	49%	99%	8%	73%	52%	10%	10%	85%	6%	99%	Nil cases	62%	97 (6%)
2012	49%	99%	9%	74%	53%	11%	10%	84%	7%	99%	1 Meropenem	62%	113 (6%)
2013	52%	100%	10%	76%	48%	14%	10%	89%	7%	99%	Nil cases	62%	141 (7%)
2014	53%	95%	13%	75%	50%	2%	13%	82%	7%	90%	2 Meropenem	55%	160 (7%)
2015	52%	100%	13%	80%	47%	2%	12%	84%	7%	93%	Nil cases	57%	214 (8%)
K. pneumoniae													
2006	97%	99%	6%	90%	92%	8%	1%	94%	2%	99%	Nil cases	82%	3 (1%)
2007	99%	99%	6%	89%	58%	17%	3%	94%	3%	99%	Nil cases	80%	7 (3%)
2008	100%	99%	7%	84%	53%	7%	3%	95%	3%	99%	1 Meropenem	77%	7 (3%)
2009	97%	100%	3%	84%	67%	0%	3%	96%	3%	100%	1 Meropenem	78%	6 (2%)
2010	99%	99%	5%	79%	80%	7%	3%	96%	6%	97%	1 Meropenem	73%	13 (4%)
2011	98%	99%	9%	72%	65%	6%	7%	86%	5%	98%	Nil cases	64%	13 (5%)
2012	99%	99%	9%	72%	64%	9%	7%	82%	3%	99%	5 Meropenem	62%	15 (5%)
2013	99%	99%	8%	70%	48%	5%	4%	84%	4%	99%	2 Meropenem	60%	15 (4%)
2014	98%	94%	9%	71%	50%	0%	6%	84%	4%	90%	2 Meropenem	56%	14 (4%)
2015	99%	100%	10%	77%	71%	3%	4%	91%	3%	93%	Nil cases	56%	18 (4%)

Apart from one imipenem resistant *E. coli* isolate, all carbapenem resistant *E. coli* and *K. pneumoniae* isolates over the 10 year period were resistant to meropenem.

The number of multi-drug resistant (MDR) *E. coli* isolates (defined in this context as resistant to three or more of the antimicrobial families investigated above) increased steadily from 2% to 8% over the 10 year period, while MDR *K. pneumoniae* isolates again peaked in 2011/2012 and remained stable in the following years. For both *E. coli* and *K. pneumoniae*, multi-drug resistance was often more common in isolates from specimens collected after seven days of hospitalisation than in those collected between three and seven days hospitalisation and prior to three days hospitalisation. However, this was not a consistent trend across all years in the period, and the differences in the proportions of MDR notifications by hospitalisation duration were highly variable (Table 5).

Table 5: Proportion of *E. coli* and *K. pneumoniae* hospital stay duration at specimen collection category accounted for by MDR *E. coli* and K. pneumonia isolates, VHPSS, 2006-2015.

	MDR *E. coli*				MDR *K. pneumoniae*			
Year	% <3 days	% 3-7 days	% >7 days	% unknown/ not admitted	% <3 days	% 3-7 days	% >7 days	% unknown/ not admitted
2006	2%	1%	5%	2%	1%	4%	3%	-
2007	2%	3%	6%	2%	3%	0%	5%	-
2008	3%	8%	4%	2%	2%	8%	7%	4%
2009	5%	5%	8%	2%	1%	0%	9%	-
2010	3%	10%	7%	1%	1%	4%	19%	-
2011	5%	9%	13%	4%	4%	13%	16%	2%
2012	6%	4%	8%	5%	5%	6%	15%	-
2013	7%	10%	8%	5%	4%	6%	10%	-
2014	6%	17%	17%	7%	4%	5%	6%	3%
2015	9%	7%	13%	6%	5%	0%	2%	4%

Conclusion

As demonstrated above, the VHPSS collects valuable information on trends in the major pathogens causing invasive infections, and their associated antimicrobial resistances, in the Victorian population. However, as will be discussed further in this evaluation, a key strength of the VHPSS is its collection of unusual pathogens in bloodstream and CSF infections which are not captured by any other surveillance systems in Victoria. The data presented above is broadly representative of invasive infections in the Victorian population, although as with most surveillance systems, the data collected by the VHPSS has a number of limitations which must be considered in its interpretation. These

limitations will be discussed alongside the strengths of the VHPSS in the assessment of the VHPSS system attributes below.

System attributes

Simplicity

The simplicity of a surveillance system refers to both the system's structure and its ease of operation.[15]

Structure

As demonstrated in Figure 1 in the system description, the VHPSS has a relatively simple structure. Notifications are either sent from contributing laboratories to MDU to be checked and entered into the VHPSS database, or are created internally from relevant results extracted from MDU's LIMS. Notifications occasionally need to be checked for adherence to the case definition, but as a laboratory-based system, all notifications are "confirmed" and the only follow-up required is to obtain missing data from contributing laboratories. Training would be required for any new staff to understand the notification checking and coding process, and to learn what data is mandatory and must be followed up, but these processes are well documented and the data entry computer application is clearly laid out and easy to use. There are a number of operational issues, however, that make using the system more complex for both contributing laboratories and VHPSS staff.

Ease of operation

Four of the 14 laboratories who completed the contributing laboratory questionnaire indicated that they did not find the method they currently use to report the VHPSS straightforward. The reasons cited for this included the time-consuming nature of reporting, the amount of writing/paperwork required, and the difficulty in being able to reliably determine which isolates are clinically significant in the absence of clinical details. Unfortunately the last of these issues is dependent on the clinical information provided to the laboratory and on the expertise of the laboratory scientists, so is outside of the control of the VHPSS. Within the control of the VHPSS are the methods of notification available to contributing laboratories.

Questionnaire respondents repeatedly suggested that an online notification system would increase the ease of notifying and would reduce the time required to do so. As is discussed further in the timeliness section, this would ideally take the form of an online results upload system that can directly electronically transfer results into an MDU database. This would not only increase the ease of reporting for laboratories, but would also drastically reduce the time required for data entry and follow-up by VHPSS staff. However, this would likely be a complex system to establish and would take dedicated time and resources to develop. In the short term, MDU could develop a notification form similar in format to the current form that can be either electronically completed and submitted, or printed and submitted in hard copy (such as a fillable PDF). Electronically completed notification forms would also reduce the amount of time VHPSS staff spend trying to interpret and follow-up unclear handwriting, and could help to reduce the amount of time spent chasing missing information if drop-down menus and required fields could be incorporated into the design.

The VHPSS data management and extraction tools also reduce the simplicity of the scheme for VHPSS staff. As will be discussed further under the flexibility attribute, the system cannot download large amounts of data easily. Attempting to download more than one month of notification data at a time will result in a failed extraction. This issue makes data extraction a tedious and time-consuming process for VHPSS staff, and would be ameliorated by the development of more powerful data management and extraction systems.

Summary

The VHPSS is structurally simple, but both contributing laboratories and VHPSS staff encounter operational issues that make using the system more complex. Many of these issues would be addressed by moving the VHPSS to a new database and user interface programs that are more powerful and can facilitate direct online notification and/or transfer of results, with automatic entry of this data into the VHPSS database. In the short term, the development of a notification form that can be either electronically completed and submitted, or printed and submitted in hard copy (such as a fillable PDF) would make the notification process simpler for contributing laboratories, and may reduce time spent by VHPSS staff following up unclear or missing information.

Flexibility

A surveillance system is flexible if it can adapt to changes in operating conditions and/or information needs with little additional time, personnel, or allocated funds.[15]

Changes to operating conditions

The VHPSS can be flexible in adapting to changes in operating conditions, but consideration must be given as to how this flexibility affects other system attributes. For example, changes in staffing levels and duties within the MDU administrative team in 2015 required more administrative staff to be trained in VHPSS data entry, so that the dedicated VHPSS data management officer could also be available to complete other tasks. This increased the ability of the VHPSS to respond to changes in personnel. However, although more staff knew how to enter data, less staff time overall was allocated to VHPSS data management and entry in this period, so this flexibility came at a cost to the timeliness of data entry. Further, even if multiple staff had been available to complete VHPSS data entry in quieter periods, this flexibility would have been nullified by the design of the VHPSS data entry application, which allows only one person to enter data at a time. This restriction severely limits the capacity of the VHPSS to handle any significant increase in the number of notifications it usually receives, which would need to be considered if more laboratories were encouraged to start contributing to the scheme.

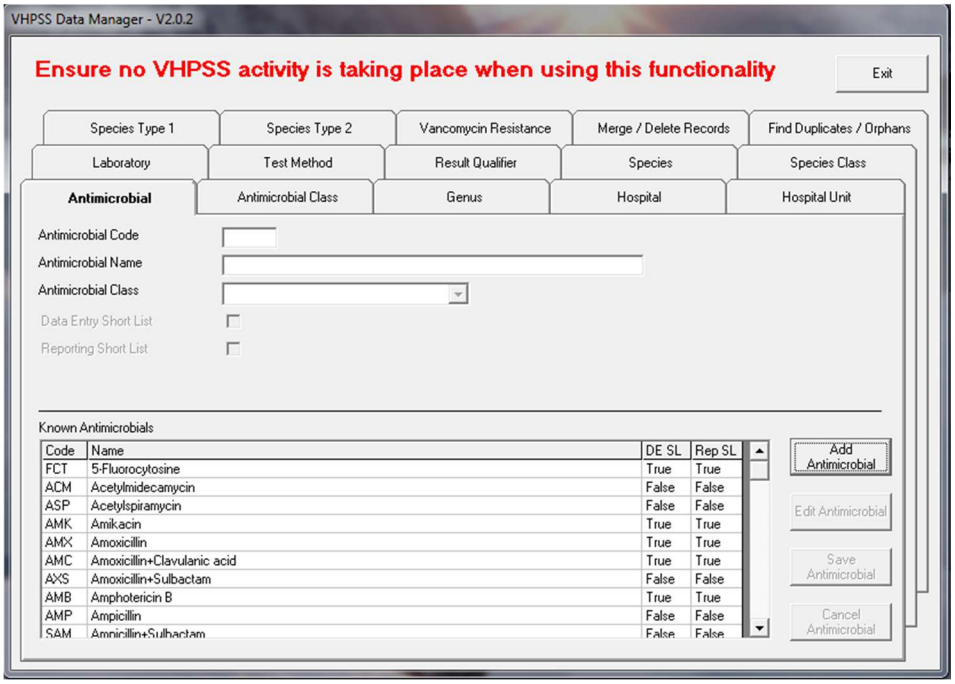
The VHPSS is also flexible in how contributing laboratories notify cases to the system, with different methods employed by different laboratories (see the description of VHPSS operations), but this flexibility can come at a cost to data quality and completeness, as some of these methods do not provide as much information as is requested on the official VHPSS notification form.

Changes in information needs

The ability of the VHPSS to adapt to changing information needs is largely dependent on its information technology (IT) infrastructure, which can be both flexible or inflexible, depending on the change required. For example, if a new antimicrobial needed to be added to the database for sensitivity reporting, this could be easily done using the Data Manager application (Figure 5). There is a tab on the home screen for adding new antimicrobials to the 'Antimicrobial' variable in the VHPSS database. However, if a whole

new variable needed to be added to the database, for example an 'Outbreak/cluster' variable, this would be very difficult as there is not a tab for adding entirely new variables. They would have to be added by altering the program code.

Figure 5: VHPSS Data Manager Application home screen



This is a particular problem because the VHPSS Data Entry, Report Generator, and Data Manager applications were created using a programming language called Visual Basic 6. This programming language is relatively old, and because it is no longer widely used and hasn't been support by the developer for over eight years, it is unfamiliar to MDU's IT staff and consequently very difficult for them to work with. They are hesitant to alter the source code for any of these applications in case this affects the overall function of the application or database. Changes made in the past have been minor (such as changing the number of digits recorded in a variable) but required significant time and care to achieve. In this respect the VHPSS is very inflexible, as no significant changes can be made to the data variables, or to what variables are included in the Report Generator application, without significant time, effort, and risk to the functionality of the applications and database.

The flexibility of the VHPSS would be greatly improved if a new database and user interface programs were built in a current (supported) programming language by MDU's IT staff. The majority of MDU's other in-house databases are MySQL databases, and the user interface applications for these are built in Microsoft Visual Studio by MDU's IT

team. Because these user interface applications are built in-house, they are designed to be exactly fit for function, and can be much more easily amended should changes in function or scope be required. Significant improvements to the functionality of the VHPSS could be built into these new applications, including allowing more than one person to enter data and to access saved data at a time. Features such as the ability to import data directly from Microsoft Excel files have the potential to streamline notification and data entry processes, and this new system could facilitate online submission and reporting of data, though current network security infrastructure may complicate this. This upgrade would bring the IT infrastructure of the VHPSS in-line with the majority of MDU's other databases, making updates and maintenance much easier for the MDU IT team.

Considerable time would need to be spent developing the database and applications, but the MDU IT team has estimated that once this is done, the transfer of the database and building of new applications should take only 2-3 months. These changes would represent a relatively inexpensive, but hugely beneficial improvement to the flexibility, acceptability, stability, simplicity, and potentially timeliness of the VHPSS.

Summary

The VHPSS has the capacity to be flexible in response to changed operating conditions if required, but the resulting effect on other system attributes should be considered. The ability of the VHPSS to respond to changes in information needs depends on the change required, but is largely limited by antiquated software. The flexibility of the VHPSS (and a number of other system attributes) would be greatly improved by transferring the VHPSS data to a MySQL database, with carefully designed new user interface applications built by the MDU IT team.

Stability

The stability of a surveillance system refers to its reliability (its ability to collect, manage, and provide data properly without failure) and its availability (the ability to be operational when it is needed).[15]

Reliability

Overall the VHPSS is a stable surveillance system that has been running consistently for over 28 years. In that time, the overall number of contributing laboratories has remained

relatively stable despite multiple changes in laboratory ownership and management. This is impressive considering the VHPSS is a voluntary scheme, and speaks to the longstanding relationships developed between MDU and contributing diagnostic laboratories over that time. There have been no changes to the case definition over the life of the scheme, and changes to the notification form have been minimal, resulting in a stable collection of data variables. As the VHPSS is included in the service agreement between MDU and the DHHS, and is incorporated into the routine work of MDU staff, funding and staff-time allocated to the management of the VHPSS have also remained relatively stable over the life of the scheme. Technologically, the VHPSS access database that holds the VHPSS data is stable and is backed up every night, and so long as the back-end programming for the user interface applications remains relatively undisturbed, they are also stable in their functioning.

Availability

Although the functioning of the user interface applications has been relatively stable, errors do occur on rare occasions, and fixing these issues can be time-consuming due to the issues outlined in the flexibility section. Upgrading the VHPSS to a new database and user interface applications would improve the stability of the system as the IT team would be able to diagnose and fix any technical problems faster and more effectively. This upgrade would also allow more than one person to access and use VHPSS data at a time, and would allow faster and more customizable report generation.

Summary

The VHPSS is a stable system, but it could be further stabilised by upgrading to more functional IT infrastructure to improve its accessibility.

Timeliness

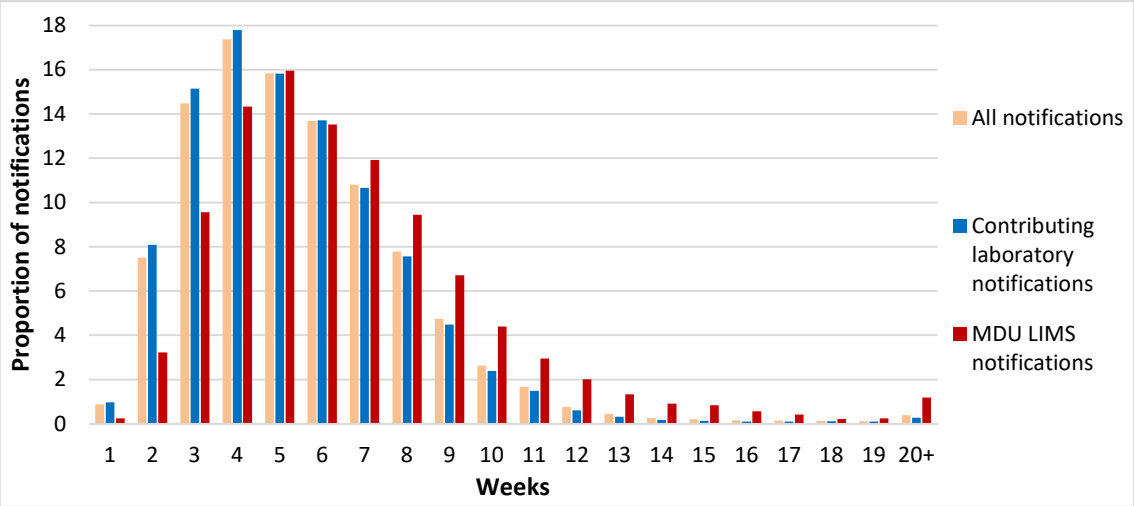
Timeliness reflects the speed with which information travels through the levels of a surveillance system.[15]

As described in the introduction, Figure 1 shows the steps through which information enters and exits the VHPSS. The VHPSS captures three data fields that can be used to determine the timeliness of data entering the system: the collection date of a specimen (as a proxy for the date of initial laboratory analysis); the date that a notification is received at MDU; and the date this notification is entered into the VHPSS. This allows

the overall amount of time between the initial specimen collection to the entry of the notification into the VHPSS to be measured, as well as the time points in between.

To provide an indication of the overall timeliness of the system over the 10 year period between 2006 and 2015, Figure 6 displays the number of weeks between specimen collection and the entry of notifications into the VHPSS. Notifications from contributing laboratories and those extracted internally from the MDU LIMS are presented separately and together.

Figure 6: Weeks between specimen collection and entry of notifications into the VHPSS database by proportion, for all notifications, notifications extracted from the MDU LIMS, and notifications from contributing laboratories 2006 – 2015



For all notifications, the majority were entered into the VHPSS within five weeks of specimen collection (56%), and a further 40% of notifications were entered within 6-10 weeks (median five weeks, range one to 77 weeks). However, it is also important to examine the timeliness of the two forms of notifications separately, as their timeliness is dependent on different factors.

Because isolates that are sent to MDU for typing are usually sent immediately after isolation by the diagnostic laboratory, the overall timeliness of internal notifications extracted from the MDU LIMS is predominantly informed by the regularity of result extraction, and the time it takes for typing results to become available. The extraction of results from the LIMS is ideally completed on a regular basis, but has a tendency to be delayed, especially if there is a backlog of notifications from contributing laboratories to be entered. Many of the tests for identifying isolates conducted by MDU can also take much longer to perform than the diagnostic tests performed by contributing

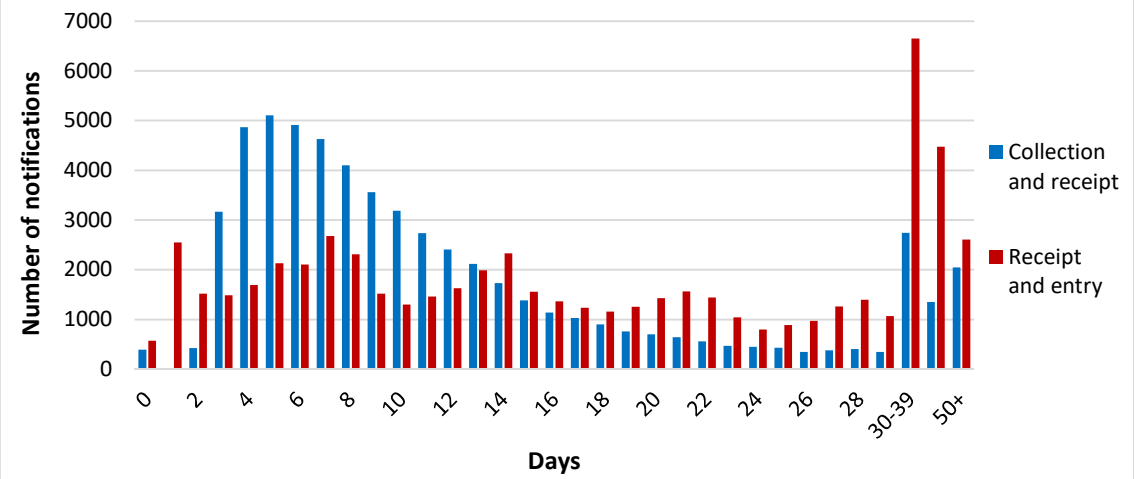
laboratories. The resulting delay in entry of these notifications into the VHPSS compared to notifications from contributing laboratories is apparent in Figure 6. Overall, 44% of notifications over the ten year period took more than five weeks to be entered into the VHPSS from date of specimen collection. When separated, 57% of notifications extracted from the MDU LIMS took more than five weeks to be entered, while for notifications from contributing laboratories this proportion was 42%.

The overall timeliness of notifications from contributing laboratories is dependent on the time it takes the laboratories to send notifications after isolating pathogens (for which the date of specimen collection is a proxy), and the time it takes for the notification to be entered into the VHPSS after receipt at MDU. A KPI exists for each of these steps:

- Timeliness of specimen collection to receipt of notification form/report by VHPSS: 100% within one month of date of isolation
- Input of data: more than 90% of notifications entered into the database within 5 days of receipt at MDU-PHL

Figure 7 below shows the number of days between specimen collection and receipt of notification at MDU (in blue), and the number of days between notification receipt and entry of data into the VHPSS (in red) for the ten year period 2006-2015. Although not meeting the 100% required by the above KPI, most notifications over the 10 year period (90%) were received at MDU within a month of sample collection. A considerable delay, however, is apparent in the entry of notifications after receipt at MDU (Figure 7). Only 17% of notifications over the 10 year period were entered within five days of receipt, which is considerably lower than the 90% required by the KPI above.

Figure 7: Number of days between specimen collection and receipt of notification at MDU, and between receipt of notification and entry into the VHPSS by number of notifications for the ten year period 2006-2015



This delay in data entry appears to stem from the view within MDU that the VHPSS is a routine part of their wider surveillance program, and that it is not a priority function within the extensive scope of MDU's day-to-day work. The system is largely considered to be a valuable passive reference database for bacterial and fungal bloodstream and CSF infections in Victoria, as opposed to a surveillance system designed to detect outbreaks in real-time (Oral communication, VHPSS Epidemiologist, September 2016). Consequently, staff time allocated to the VHPSS has gradually decreased in recent years, with dedicated VHPSS staff time often re-allocated to more urgent duties when required, which has resulted in increasing delays in data entry.

Contextually, it is important to note that this is not a new state for the VHPSS. The documents reviewed for this evaluation, including previous assessments of the VHPSS against the timeliness KPIs, indicate increasing levels of delay in data entry since 2004, suggesting timeliness has been a consistent and ongoing problem for the VHPSS. The reasons given for these delays in previous assessments also included the diversion of VHPSS staff time to other MDU tasks, alongside changes in VHPSS data management procedures and the general increase in notifications to the system.

Overall, when assessed against the relevant KPIs and scheme objectives, the timeliness of information entering the VHPSS is poor. This has an impact on the ability of the VHPSS to meet its objective to 'report possible outbreaks or clusters of a particular organism to the relevant agencies in a timely fashion'. While it is likely that any large clusters or outbreaks would be recognised through the 'eyeballing' of notifications by the VHPSS

epidemiologist, the poor timeliness of data entry and analysis would not allow for the detection of smaller clusters or outbreaks. Further, although the quality of data in the VHPSS is high (as discussed further in the data quality section) the lack of timely data also impacts on the ability of the VHPSS to meet its objective to 'operate the scheme according to quality principles, to ensure maximum data quality and timely and accurate reporting'.

Should the objectives and KPI's of the VHPSS remain the same following this evaluation, it is recommend that resources be allocated to fund additional MDU staff time for the required number of hours/days so that VHPSS staff can return to their dedicated duties. However, as has also been suggested in the previous internal reviews of VHPSS timeliness, it may be prudent to review and amend the current KPIs and objectives of the system once its future purpose and direction has been decided. If the system is to continue operating as it currently does - primarily acting as a reference database that is not designed to provide real-time information on the incidence of infections - the KPIs should be changed to reflect this with less focus on immediate data entry and more focus on data quality and regular reporting. When examined in the context of this function, realistically the timeliness of data entering the VHPSS is satisfactory. The scheme is able to report relatively reliably on data up to the end of the previous quarter of the year, which especially for diseases that are not mandatorily notifiable to the DHHS, is reasonable.

As has been noted, a small contributor the poor timeliness of data entering the scheme is a delay in receiving some notifications from contributing laboratories. This delay is likely due to the practice employed by many of the contributing laboratories of batch-sending their notifications, which can result in smaller laboratories especially waiting a month or longer to collect enough notifications to send together. It is difficult, however, to determine how to improve this delay without additionally burdening, and subsequently discouraging, laboratories who are contributing to the VHPSS voluntarily.

One option that may make reporting less burdensome to laboratories, and might consequently increase notification frequency and acceptability, is encouraging laboratories to send their own results print-outs instead of filling in the VHPSS form manually. Some of the larger laboratories already do this, and VHPSS staff find these reports easier to read, check, and enter, as they are much clearer than some of the

handwritten VHPSS forms and often have more complete patient data. There is also less time spent following up notifications where data is missing, so data is entered faster.

The disadvantage of this option is that laboratory result print-outs often only report the few antimicrobial sensitivities that are relevant for clinical treatment, representing a significant loss of antimicrobial sensitivity information. Result print-outs also tend not to include clinical information, which is requested (where provided to the laboratory) on the VHPSS card. Although not all of the clinical information provided to laboratories is useful, the VHPSS has received clinical information for an average of 34% of notifications over the 10 year period, which constitutes another considerable loss of information should this field no longer be included in the data collection process. As part of the review of the future purpose and direction of the VHPSS, the usefulness of this data will need to be considered against the potential increase to timeliness.

Ultimately, some form of email, online upload or submission, or direct electronic results extraction and transfer would probably be the most efficient form of notifying for many laboratories. If this system could also be used by contributing laboratories and other stakeholders to generate their own reports, this may increase engagement with, and contribution to, the VHPSS. Additionally, if there was a program that could then take this electronic information and enter it directly into a VHPSS database, this would drastically reduce the staff time required for data entry. As discussed in the flexibility section of this evaluation, the VHPSS could be relatively easily transferred to another type of database and user-interface programs that could support many of these required functions. In the meantime, responses to the contributing laboratory questionnaire indicated that most laboratories who participated would prefer to notify using a form that can be completed and submitted either electronically or in hardcopy. A fillable/editable PDF VHPSS form that fulfils this function would not be difficult or expensive to produce, and may make the notification process more timely and acceptable for contributing laboratories.

The reduction in staff time allocated to the VHPSS, alongside the termination of the Victorian Infectious Diseases Bulletin (VIDB) at the end of 2014, in which VHPSS biannual reports were regularly published from 2008, has also affected the timeliness of information exiting the system. The VHPSS is no longer meeting its objective ‘to report the current epidemiology of bloodstream and CSF infections to laboratory and clinical

staff throughout Victoria and in a regular and timely fashion'. No reports have been produced since the termination of the VIDB, excepting routine reporting to one contributing laboratory and responses to requests for information (RFIs).

Further, half of the laboratories (7/14) who responded to the laboratory questionnaire stated that they do not receive any feedback from the VHPSS, or that it is only sent to a parent laboratory, which affects the acceptability of the scheme for these laboratories (discussed further below). The importance of reporting back to surveillance contributors was highlighted in the original proposal for the establishment of the VHPSS, which stated that 'if people are to continue to support a scheme they need evidence of its value and that their assistance is appreciated'.[13 p7] To ensure both the usefulness and acceptability of the VHPSS to stakeholders, it is essential that regular reporting be reinstated as soon as possible.

The KPIs state that reporting should be completed quarterly, which corresponds with the majority preference for quarterly reporting expressed in the contributing laboratory questionnaire. It is also recommended that these reports are not only distributed directly to all contributing laboratories, but also to other potentially interested stakeholder (e.g. non-contributing laboratories and other related surveillance systems) and are published on a publicly accessible website, such as the MDU website currently under construction. Making these reports more widely accessible may increase awareness and utilisation of the VHPSS, which could potentially have the effect of encouraging laboratories not currently contributing to consider doing so.

The timeliness of responses to external RFIs could not be assessed as this information has not always been consistently documented. To assists in assessing this, a question regarding satisfaction with RFIs was included on the contributing laboratory survey. Unfortunately only one of the laboratories that participated in the survey had recently submitted an RFI, but they did state that the response to the RFI was timely and fulfilled their requirements.

Summary

The timeliness of the VHPSS in the ten year period between 2006 and 2015 measured against current VHPSS KPIs and objectives was poor, both in regards to information entering the system and exiting the system. To improve the timeliness of the VHPSS to

meet the relevant KPIs and objectives of the system, an increase in the resources for data management, entry, cleaning, and reporting is recommended, as is exploring the ways in which notifying might be made easier for contributing laboratories so that they may contribute more frequently without additional burden. Quarterly reporting should be reinstated and reports made publicly available, and the VHPSS objectives and KPIs relating to timeliness should be reviewed to ensure they are relevant to the future purpose and direction of the VHPSS.

Acceptability

Acceptability reflects the willingness of persons and organisations to participate in the surveillance system, including those who work within the organisation that hosts the system. The acceptability of the system can be determined both by examining the level and quality of participation in the system, and through direct consultation with stakeholders.[15]

Participation

Overall, the level and quality of participation in the VHPSS indicates that it is acceptable. Despite being a voluntary scheme, the majority of diagnostic laboratories in Victoria participate, with only three major hospital laboratories and one private laboratory currently not participating. The overall quality of data submitted to the VHPSS is high, though as discussed further in the data quality section, there are some issues with data completeness.

Stakeholder consultation

Consultations with stakeholders through the contributing laboratory questionnaire revealed that nine out of twelve contributing laboratories who participated in the laboratory survey said that they thought their contribution to the scheme was worthwhile, and open-ended responses emphasised the importance of VHPSS data for reviewing trends in invasive disease and antimicrobial resistance.

However, stakeholder consultations also revealed some key issues that impact on the acceptability of the scheme for both contributing and non-contributing laboratories. Of the three contributing laboratories that did not report that they thought their participation was worthwhile, one described their participation as a ‘chore’ that was hard to stay on top of in a busy laboratory, and noted that direct electronic reporting

would make contributing easier. This theme was reiterated elsewhere in the questionnaire, with two contributing laboratories stating that the time required to notify limited the comprehensiveness of their reporting, and nine contributing laboratories indicating that they wanted to change to another method of notification because they believed it would be less time-consuming (eight stated that it would also be easier). Further, both of the non-contributing laboratories who participated in the survey stated that a primary barrier to their participation in the scheme is the resources it would require for them to do so. They both indicated that should the VHPSS be able to arrange (and fund) some form of automated electronic notification process that could extract the data from the laboratory without direct laboratory staff involvement, they might be able to participate.

A lack of feedback was also noted to be an issue by both the contributing and non-contributing laboratories. Another of the three laboratories that did not report that they thought their participation was worthwhile stated that they 'don't get anything out of' participating (the last of these three laboratories gave a neutral response). This laboratory was one of five contributing laboratories that reported not receiving any feedback from the VHPSS, and an additional two laboratories reported that the feedback they did receive was not informative or useful.

Responses by the non-contributing laboratories also touched on this, with both stating that when the scheme first started there was a lack of feedback, and that they were unsure of how the data was used or for exactly what purpose the data was being collected. One non-contributing laboratory stated that the feedback they had received was interesting, but was not actually useful to the laboratory or the hospital's clinicians, and that there was concern about the validity of the data and its epidemiological application given that it was retrospective and did not include all cases. This laboratory suggested that if the structure and objectives of the VHPSS were assessed and re-defined to answer clear and specific public health questions, this might make the scheme more valuable and attractive to participate in.

It is clear that to increase the acceptability of the VHPSS for contributing laboratories the notification process must be amended to be less time-consuming and easier for laboratories to complete. Options for a new notification process have been discussed in the timeliness section, but if laboratories could be financially and technically supported

to establish automatic data extraction, this might even facilitate contributions from currently non-contributing laboratories. Targeted, useful, and regular reporting also needs to be re-established as soon as possible so that contributing laboratories can be informed about what their data is used for and benefit from its analysis. Sharing these reports with non-contributing laboratories, clinicians, other stakeholders, and even the general public should increase awareness of the VHPSS and the usefulness of its data, and may perhaps even also act to encourage further participation and potentially increase funding for the scheme.

To facilitate this, resources need to be allocated within MDU to developing and improving the notification process, ideally including upgrading to a new database and custom-built user-interface programs which can further facilitate and support new notification processes. Adequate resources also need to be allocated to staff time for VHPSS data entry, cleaning, management, and reporting, so that timely, relevant, and accurate reports can be disseminated to stakeholders. These actions would also act to increase the acceptability of the VHPSS to those who work with it, as insufficient time to complete the required daily functions of the scheme, and working with ill-fitting, antiquated user interface programs are the key concerns of VHPSS staff (Oral communications, VHPSS Epidemiologist September 2016, VHPSS Data Manager November 2016).

Summary

While the VHPSS is generally acceptable overall, improvements to the notification process and the reinstatement of regular useful feedback would significantly increase the acceptability of the scheme for stakeholders.

Sensitivity

The sensitivity of a surveillance system refers both to the proportion of cases in the population that the system detects, and to the ability of the system to detect outbreaks, including the ability to monitor change in the number of cases over time.[15]

Case detection

The proportion of case isolates in the population that the VHPSS detects varies by organism. For organisms that are routinely sent to MDU for typing or identification (i.e. *Salmonella* species*, H. influenza, N. meningitides, L. monocytogenes, and S.*

pneumoniae) the VHPSS captures close to 100% of case isolates, as almost all eligible isolates in Victoria are sent to MDU for further typing and are recorded in the VHPSS. For organisms not routinely sent to MDU, the primary determinant of the sensitivity of the VHPSS is the number of laboratories in Victoria that contribute to the scheme and the proportion of cases in the Victorian population these laboratories test.

It is difficult to track over time what proportion of laboratories in Victoria have contributed, as some laboratories have been intermittent in their contributions, and many laboratories have undergone changes in ownership and/or amalgamations with other laboratory groups. Currently, most laboratories in Victoria contribute to the VHPSS, with the exception of three major hospital laboratories (all located in metropolitan Melbourne) and one private laboratory. Previous internal documents have estimated that notifications from contributing laboratories represent 60-70% of all eligible blood culture and CSF isolates in Victoria not routinely sent to MDU. The results of two recent studies conducted within MDU, however, suggest that they represent closer to 80%.

The Victorian Vancomycin Resistant Enterococci (VRE) Snapshot Study conducted in 2015 aimed to determine the prevalence and genomic diversity of vancomycin resistant *E. faecium*, and the incidence of *E. faecium* bacteraemia, in Victoria. MDU asked all Victorian diagnostic microbiology laboratories to submit all vancomycin-resistant *E. faecium* isolates from any specimen, and all vancomycin-susceptible *E. faecium* blood culture isolates, collected between the 10th of November 2015 and the 9th of December 2015 to MDU. Reviewing the bacteraemia submissions, the VHPSS epidemiologist noted that 85% of the submissions to the snapshot study came from laboratories that contribute to the VHPSS, and so represented notifications the VHPSS would normally receive (Oral communication, VHPSS Epidemiologist, December 2016).

This finding was supported by the results of a study by Guilieri et al, who used VHPSS data to investigate trends of antimicrobial resistance in gram-positive bacterial bloodstream infections, and applied Bayesian modelling to infer incidence data for these infections at population level.[16] Using data from laboratories who had contributed to the VHPSS consistently over the study period, the model was designed to estimate the data that was missing from non-contributing laboratories. This methodology estimated that the VHPSS captures approximately 75-80% of bloodstream infections in Victoria.

The researchers also compared the number of notifications of *Streptococcus pneumoniae* made to the VHPSS in the study period to the number of Victorian cases reported by the National Notifiable Diseases Surveillance System (NNDSS). As expected, Guilieri et al found less than 5% discrepancy between these numbers, supporting the assumption that the VHPSS captures close to 100% of bloodstream and CSF infections caused by notifiable conditions that are routinely sent to MDU for typing.

It is not just the number of positive cases detected by the system, however, that determines its sensitivity, but also whether those results accurately represent the true number of cases in the population. This is influenced by both the number of cases in the population that are actually tested, and the sensitivity of the tests themselves. In general, bloodstream and CSF infections result in severe physical symptoms, so it can be assumed that most cases in the population will present to a health service for treatment.[4] If a bloodstream or CSF infection is suspected, it is then standard procedure to take a sample to identify the pathogen, and if relevant, its antimicrobial susceptibilities, for the provision of the most effective treatment (Oral communication, VHPSS Epidemiologist, November 2016). As such, it can be assumed that almost all cases of bacterial or fungal bloodstream or CSF infection in the population present for treatment and are tested.

The sensitivity of blood culture tests, however, is variable and depends on a number of factors including the organism itself, the type of infection, the point of infection at which the sample is taken, whether antibiotic treatment has been administered before the sample is taken, and how much fluid the sample captures.[17-19] For example, the bacterial burden of *Salmonella* in blood samples is reported to generally be low.[17] Consequently, the sensitivity of blood culture tests for *Salmonella* is relatively low, estimated at 60-80% in the first week of illness, and dropping to 20-30% at subsequent time points.[17]

The probability of detecting the organism is increased as the volume of blood in the sample increases, but if antibiotics have been administered to the patient prior to sampling, the bacterial yield and likelihood of organism detection is substantially diminished.[17-19] If test sensitivity is low, laboratory-based surveillance may not detect every true case in the population even if all cases are tested. As such, it can be difficult to determine the true burden of disease in the population, which is an issue encountered by most infectious diseases surveillance systems.[20] The sensitivity of tests

used by contributing diagnostic laboratories is outside of the control of the VHPSS, which can only endeavour to capture as many cases of infection as possible and acknowledge the potential effects of test sensitivity when analysing and presenting data.

For a voluntary surveillance scheme, detecting between 80% and 100% of case isolates represents a relatively high sensitivity, though this would of course be improved if all laboratories in Victoria contributed to the scheme. However, as discussed in the acceptability section, the non-contributing hospital laboratories do not have the capacity to contribute to the VHPSS using the current notification methods, and as discussed in the flexibility section, the VHPSS would not have the capacity to manually check and enter such a significant number of additional notifications.

Facilitating notifications from these hospital laboratories would require the VHPSS to be able to automatically extract the relevant data from their systems without much assistance from the laboratories, and to develop a more efficient method of data entry (most likely electronic). While this would be possible to implement, especially if the switch to a new VHPSS database and user interface programs was undertaken, this extraction process would require significant resources to establish and would require regular data checks and maintenance at each laboratory. Whether the contribution of all laboratories in Victoria to the VHPSS is worth the resources required to facilitate it should be discussed alongside the future aims, objectives, and development of the VHPSS following this evaluation.

Outbreak detection

If notifications from the currently non-contributing major hospital laboratories were able to be facilitated, this would also increase the sensitivity of the VHPSS in its ability to detect outbreaks. Currently, the poor timeliness of data being received and entered into the VHPSS, and the lack of information from three major public hospital laboratories, limits the ability of the VHPSS to detect clusters or outbreaks. As described in the timeliness section, although the daily process of ‘eyeballing’ notifications might alert the VHPSS epidemiologist to a large and sudden outbreak, or an outbreak of an unusual organism, the entry of data into the VHPSS is otherwise not timely enough to detect outbreaks in real-time. The data is also not currently reviewed or analysed frequently enough to detect elevated case numbers or unusual patterns that are not recognized through the eyeballing process, and even if the data were reviewed

frequently, the VHPSS may not receive enough clinical or risk factor information on cases to determine links between them. Further, if for some reason the majority of cases in a given outbreak presented to any of the three major non-contributing hospitals, the VHPSS may not be able to detect the outbreak from the cases that it captures alone.

These issues impact on the ability of the VHPSS to meet its objective to 'report possible outbreaks or clusters of a particular organism to the relevant agencies in a timely fashion'. Given that this was also highlighted as a problem in the 2003 evaluation, it appears outbreak detection is an ongoing weakness of the VHPSS and that this objective may have become unrealistic. One of the strengths of the VHPSS is its wealth of historical data and its ability to monitor trends over time. As stated in the 2003 evaluation, perhaps the VHPSS should be 'viewed as an adjunct to outbreak investigations', providing historical and comparative data to support outbreak investigations rather than as an outbreak detection system. Should it be decided following this evaluation that the VHPSS will continue to function as it currently does, the relevance and achievability of this objective should be reviewed, and it may be most appropriate to remove or reword it to be more in line with the capacity of the VHPSS.

Summary

Depending on the organism, the VHPSS captures between an estimated 80% and 100% of bacterial and fungal bloodstream and CSF infections in the population. This makes the system relatively sensitive, although the potential effect of test sensitivity on the data must be recognized. The VHPSS is restricted in its ability to detect and report outbreaks due to poor timeliness of data entry, limited clinical and risk factor information, and not receiving notifications from three major hospital laboratories, but remains a valuable adjunct to outbreak investigations with its wealth of historical data and ability to monitor trends over time.

Increasing the sensitivity of the VHPSS would require significant investment to facilitate notifications from the currently non-contributing hospital laboratories, and to develop and resource a more efficient data entry process. Whether increasing the sensitivity of the VHPSS is worth the resources required to do so, and whether the objective of the system pertaining to outbreak detection should be retained, should be discussed alongside the future aims, objectives, and development of the VHPSS following this evaluation.

Representativeness

A surveillance system is representative if it accurately describes the occurrence of the health-related event over time and its distribution in the population by place and person.[15]

Having captured between 60% and 80% of bacterial and fungal bloodstream and CSF infections not routinely sent to MDU from across Victoria since 1988, the VHPSS is able to relatively accurately describe the occurrence of these infections over time and by place and person. Consideration must always be given, however, to the possibility that there may be differences between cases that are captured by the VHPSS and those that are not, either in regards to test sensitivity, or to cases who present to any health care facilities not serviced by contributing laboratories.

For example, if a test for a certain organism has low sensitivity and fails to diagnose a proportion of true cases, this can contribute to an underrepresentation of disease burden in the population, and may result in an overrepresentation of those with severe infections and/or those in groups particularly vulnerable to infection. Conversely, the VHPSS could be underrepresenting those with severe infections, including cases with greater resistance to antimicrobials, if these cases are more often referred to the large metropolitan hospitals whose laboratories do not contribute to the scheme.

Hospitals not represented in the VHPSS data may also see cases from different and/or more vulnerable groups of patients to those that are represented, either because of geographic location or through the provision of specialised programs, such as prisoner health or drug and alcohol programs. Should the epidemiology of bloodstream or CSF infection be different in these groups, the VHPSS would not be representative of them. Additionally, these potential differences would vary for each organism captured by the VHPSS (as test sensitivity, epidemiology, and clinical presentations are different for each disease) making determining their impact on the representativeness of the system as whole even more complex.

Summary

Having collected a relatively high proportion of cases for over 28 years, the VHPSS is likely to be representative of bacterial and fungal bloodstream and CSF infections in Victoria. Without some form of comparative study, however, it is impossible to know

whether there is any pattern to cases missed by the VHPSS that would make the scheme unrepresentative of disease in the Victorian population. As with sensitivity, the representativeness of the VHPSS would be improved if all laboratories in Victoria were to contribute, so the value of this improvement needs to be weighed against its costs and relevance to the future direction and purpose of the VHPSS following this evaluation.

Data quality

Data quality reflects the completeness and validity of the data recorded in the system.[15]

Overall, the quality of data in the VHPSS is high. Although routine cleaning of data has become less frequent with the diversion of data entry and management staff time to other duties (as described in the timeliness section), it is still eventually completed and results in a high level of accuracy and validity in the historical data. Supporting this, a random selection of 50 records from the 2015 notifications found less than 3% errors in total for organism, collection date, gender, date of birth, and specimen fields, in line with the requirements of the data quality KPI.

Completeness

The data completeness KPI requires that the VHPSS is to 'contain more than 90% of bloodstream and CSF isolates processed by contributing laboratories'. To ascertain whether the VHPSS is receiving this, contributing laboratories were asked in the questionnaire what proportion of their eligible blood and CSF isolates are notified to the VHPSS. There seems to have been some misinterpretation of this question, but the majority of laboratories who participated stated that they notify 90% of eligible isolates or over for blood (12/14 laboratories) and 95% or over for CSF isolates (8/14 laboratories).

One laboratory stated that they only sent 70% of blood isolates (though 100% of CSF isolates), and indicated in a following question that it was the 'hands-on time' required to notify that limited the comprehensiveness of their reporting. This laboratory also stated that they would prefer to use an electronic VHPSS notification form to notify were it available. If such a form saved time for the laboratory, this might result in a higher proportion of their eligible blood isolates being notified to the system.

The completeness of core variables in the 2006-2015 dataset was also examined (Table 6). Patient identification (ID) code, date of birth (DOB), and sex were 100% complete for all years, as were the details of the notifying laboratory, sample, and isolate. Postcode completeness improved following an amendment to one particular laboratory's notification form in 2012.

Table 6: Completeness of core data variables, VHPSS, 2006-2015

Variable	Data completeness (%) by year									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Patient ID	100	100	100	100	100	100	100	100	100	100
DOB	100	100	100	100	100	100	100	100	100	100
Sex	100	100	100	100	100	100	100	100	100	100
Postcode	88.5	85.7	84.8	84.5	87	96.6	99.6	99.5	99.7	99.4
Species name	100	100	100	100	100	100	100	100	100	100
Collection site	100	100	100	100	100	100	100	100	100	100
Collection date	100	100	100	100	100	100	100	100	100	100
Notifying lab	100	100	100	100	100	100	100	100	100	100
Hospital name	99.9	99	99	99	99	98.5	98.2	98.7	99.2	99
UR number	99.2	98.3	97.8	97.8	97.9	97.7	97.3	97.7	98.4	98.2
Date of admission	95.3	95.3	91.1	88	88.2	80.4	79.3	76.5	77.3	77.5
Hospital unit	73.6	71.1	68.5	67.2	69.4	76.1	76.1	77.1	75.8	75.8
Clinical comment	35.4	32.5	30.2	31	37	43.3	43	40.4	27.6	25

Date of admission completeness has decreased over the 10 year period, which can be predominantly attributed to three large contributing laboratories (who together submit approximately 50% of VHPSS notifications per year) moving to using their own laboratory reports to notify. These laboratories account for 95% of records missing a date of admission from 2013-2015, with the VHPSS receiving admission dates for only 24%, 54%, and 77% of notifications from these three labs respectively. Comparatively, admission date is provided for 94% or more of notifications from other laboratories. This limits the ability of the VHPSS to meet its objective to 'classify infections according to length of hospitalisations prior to collection of diagnostic specimen', which in turn limits the ability of the VHPSs to provide useful information on trends in community vs hospital acquisition of infection (discussed further in the usefulness section). The VHPSS is also limited in its ability to determine any patterns of infection in hospital patient groups, as data completeness is similarly low for the hospital unit variable.

The proportion of notifications including clinical comments has also recently decreased, although laboratories are often not provided with clinical information on test request

forms, and when they are, the comments are often minimal. Clinical comments can be helpful in providing contextualising information for the infection, including potential risk factors, which can help to determine whether there are epidemiological links between patients or whether an infection is hospital-acquired. Their main significance for the VHPSS, however, is in interpreting some antimicrobial sensitivity test results. For penicillin sensitivity in *Streptococcus pneumoniae* isolates, for example, the interpretation of an MIC (minimal inhibitory concentration) value changes depending on the clinical syndrome (pneumonia, meningitis, or other symptoms). As such, if there is no clinical information available to contextualise the interpretation, this result may have to be entered as 'not interpretable', wasting important antimicrobial sensitivity data. Only 35% to 43% of *Streptococcus pneumoniae* notifications to the VHPSS from 2012-2015 had clinical information.

For laboratories that contribute using the VHPSS form, the completeness of these fields could be improved by implementing an electronic or web-based notification form that requires these fields to be completed before submission (with options included to indicate where data is not available). Additionally, building this form to require all core information would drastically reduce the amount of time the VHPSS data manager currently spends following up missing information. For laboratories that contribute via their own report, a report that includes both admission date and hospital unit information would ideally be constructed. However, it is recognised that hospital and clinical information is difficult to access for some laboratories depending on their IT systems and access to hospital databases, and so completing these fields may not be possible, or may require too much time to search for information. As an alternative option, laboratories or hospitals may be able to produce a bulk extraction of admission dates and hospital unit codes for relevant patients which could then be matched with VHPSS data.

Within the context of the future direction and use of the VHPSS, the usefulness of all of these fields should be considered against the resource costs to both the contributing laboratories and to VHPSS staff to increase their completeness. It was suggested in a previous evaluation of the VHPSS that 'The scheme would benefit from a narrowing of its objectives, focussing on its strengths and sacrificing information that is poorly reported'. As will be discussed further in the usefulness section, this may be the best

course of action if the incompleteness of these variables makes them functionally useless.

Validity

All notifications to the VHPSS come from accredited diagnostic laboratories, so it is assumed that their diagnostic results are valid. However, there are some issues surrounding the classification of cases and the comparability of antimicrobial sensitivity test results that need to be considered when interpreting VHPSS data.

First is the potential for the VHPSS to be reporting cases that actually represent contaminants, and to be missing true cases caused by common contaminants. Contaminants in this context refer to organisms from outside the bloodstream or CSF (commonly those that live on the skin) that have contaminated a blood or CSF sample. Coagulase-negative staphylococci are the most common blood culture contaminants, and it can sometimes be difficult to determine whether growth of these organisms in culture represent a true infection or a contamination. As mentioned in the description of the VHPSS, laboratories are asked to determine the clinical significance of these isolates in the context of the clinical information they have. However, laboratories often aren't provided with clinical information, which may result in the reporting of contaminants as cases, or the exclusion of true cases thought to be contaminants.

Further complicating this issue is the now widespread use of the MALDI-TOF machine, which can distinguish the species of coagulase-negative staphylococci to a much greater extent, and much faster, than previous methods. As a result, isolates that previously would have been reported as just coagulase-negative *staphylococcus*, and consequently likely determined to be contaminants, are now being further speciated. These (often unfamiliar) species results may then appear to represent an unusual infection rather than a contamination, and are thus more likely to be notified as a case (Oral communication, VHPSS Epidemiologist, September 2016). Unfortunately this issue is largely out of the control of the VHPSS, so it was reassuring to find that responses to the VHPSS contributing laboratory survey indicated that the majority of laboratories (10/14) believe they do not report contaminants to the VHPSS. However, three laboratories recognised that they likely sometimes reported contaminants, and one laboratory stated that they do report contaminants, confirming that the potential misclassification of contaminants must be taken into account when analysing VHPSS data.

Secondly, there are issues surrounding the comparability of antimicrobial sensitivity test results notified to the VHPSS. Different laboratories use different methods to determine antimicrobial sensitivity (Vitek, Disc Diffusion, E-test etc.) and either report an isolate as S (sensitive), I (intermediate), or R (resistant) for the relevant antimicrobials, or report an MIC value with or without and interpretation. There are also multiple different interpretative schemes employed by laboratories (European Committee on Antimicrobial Sensitivity Testing (EUCAST), Clinical and Laboratory Standards Institute (CLSI), and Calibrated Dichotomous Sensitivity test method (CDS)), and more than one scheme may be employed by a laboratory. It is not noted on the VHPSS notification form which interpretive scheme/s has been employed.

Although the schemes are largely comparable, they can differ in cases where a result is close to the cut-off mark, so one laboratory might interpret a result as sensitive, and another interpret the result as intermediate. As such, sensitivity test results notified to the VHPSS can be difficult to compare and can only be done so with strict caveats. These differences can also contribute to difficulties in de-duplicating records, as a person may have tests conducted by two different laboratories within a 14 day period which return slightly different sensitivity results. This can make it difficult to determine whether these notifications actually represent the same infection, and may result in an over-estimation of case numbers if they are counted separately.

Additionally, although the VHPSS notification form explicitly requests that laboratories notify results of all antimicrobials tested, contributing laboratories notify the VHPSS of antimicrobial sensitivity test results to different extents. Of those laboratories who completed the questionnaire, only half (7/14) reported they provide all sensitivity results, while four said they provide just those results given to clinicians, and three only provide those thought to be relevant to the VHPSS. So although an objective of the VHPSS is to ‘monitor antibiotic resistance in invasive pathogens, as reported by primary diagnostic laboratories’, it must be acknowledged that the data is incomplete and has not been systematically produced and interpreted, which may limit the conclusions that can be drawn from it.

The completeness of antimicrobial sensitivity test results could potentially be increased as contributing laboratories store this data, but it would need to be discussed with them whether providing this information would be possible given their resource constraints

and laboratory IT systems. One option may be for laboratories to submit the Vitek (or other such sensitivity testing method) data for all relevant isolates in a batch, which can then be matched to notifications by VHPSS staff, but again this would depend on how simple extracting this data is for the laboratory.

Summary

The overall quality of the data in the VHPSS is high. However, the incompleteness of some variables, difficulties in determining the significance of common contaminants, and issues surrounding the comparability of antimicrobial sensitivity test results can limit the usefulness of this data, as it cannot be interpreted without significant caveats. While the potential misclassification of contaminants and the unsystematic production and interpretation of antimicrobial sensitivity test results is largely out of the VHPSS' control, the completeness of patient and specimen variables and antimicrobial sensitivity test results could potentially be improved. This might place an unsustainable burden on contributing laboratories, however, so whether some of these variables should continue to be collected or not needs to be considered in the context of the future use and direction of the VHPSS.

Usefulness

A surveillance system is useful if it contributes to the prevention and control of adverse health-events, including improving the understanding of the public health implications of the event, and determining whether the event is of public health importance.[15]

The VHPSS aims to be useful by monitoring the causative organisms of both community and hospital-acquired bloodstream and CSF infections in Victoria to detect clusters of infection, and to increase knowledge about the local trends in these organisms and their antimicrobial resistances to assist in determining whether they are of public health importance. To assess whether the VHPSS is achieving this aim, it is important to examine how the VHPSS is performing against its stated objectives and KPIs, and how this impacts on its usefulness and utilisation. It is also important to consider the usefulness of the VHPSS in the context of other surveillance systems currently operating in Victoria, to ensure that the VHPSS is continuing to collect useful information that is not captured elsewhere.

Taking into account the findings of this evaluation, Table 7 presents a summary of how the VHPSS is currently performing against its objectives and KPIs, coloured to represent the extent to which they are being fulfilled.

Table 7: List of VHPSS objectives and KPIs and whether they are being met under the current functioning of the scheme

Objective	Is the objective being met?
To identify trends in the epidemiology of human bacterial/fungal bloodstream and CSF infections acquired in diverse Victorian community and health-care settings	**Yes** - though limited by some data quality issues such as being able to determine which notifications are community acquired (missing dates of admission and/or clinical information)
To monitor antibiotic resistance in invasive pathogens, as reported by primary diagnostic laboratories, and to actively enhance this surveillance in key pathogens from time to time	**Yes** - though limited by the variability in antibiotic sensitivity test results reported by diagnostic laboratories
To classify infections according to length of hospitalisations prior to collection of diagnostic specimen	**Moderately** - Data completeness for the date of admission variable prevents this for approximately a quarter of notifications
To monitor the emergence of important pathogens and to explore geographic or temporally clustered infection	**Moderately** - clusters may not be recognised as they occur, and clusters associated with non-contributing laboratories would not be recognised
To report possible outbreaks or clusters of a particular organism to the relevant agencies in a timely fashion	**No** - currently the timeliness of data entry and analysis would not allow the VHPSS to recognise and report any outbreaks or clusters in a timely fashion
To enhance existing surveillance of disease notifiable under the Heath (Infectious Diseases) Regulations	**Yes** - especially in regards to antimicrobial susceptibility data
To report the current epidemiology of bloodstream and CSF infections to laboratory and clinical staff throughout Victoria in a regular and timely fashion	**No** - reports are not currently being produced
To operate the scheme according to quality principles, to ensure maximum data quality and timely and accurate reporting	**Moderately** - Data is generally of a high quality, but data entry, analysis, and reporting are not timely
Key Performance Indicator (KPI)	**Is the KPI being met?**
Input of data: more than 90% of notifications entered into the database within 5 days of receipt at MDU-PHL	**No**
Accuracy and validity of data: no more than 3% errors in total for organism, collection date, gender, date of birth/age, specimen fields in a random sample of 50 VHPSS records	**Yes**
Timeliness (response to external data requests): more than 90% within three working days	**Yes**
Output of data: distribution of four quarterly reports covering human isolates (within two months of the end of the specified three month period)	**No**
Timeliness (specimen collection to receipts of form/report by VHPSS): 100% within one month of date of isolation	**No**
Completeness of data (cases): the VHPSS to contain more than 90% of bloodstream and CSF isolates processed by contributing laboratories	**No**

Despite some data quality limitations, the VHPSS is largely fulfilling its objectives to identify trends in the epidemiology of bacterial and fungal bloodstream and CSF infections in the Victorian population, and to monitor antibiotic resistance in these pathogens. The latter also functions as the primary enhancement to the existing DHHS infectious diseases surveillance, as AMR results are not collected and/or recorded for all notifiable conditions (Oral communication, Victorian Government Department of Health and Human Services Epidemiologist, February 2017). The fulfilment of these objectives has allowed the VHPSS to be used to answer a number of queries and research questions, recent examples of which include a study to determine the incidence of gram-negative bloodstream infections in Victoria and their antimicrobial resistance trends,[16] and two instances where the VHPSS was queried to determine whether there may have been Victorian cases linked to medical equipment contamination events.

The ability of the VHPSS to classify events as either hospital or community-acquired, however, is only moderately fulfilled as this data is incomplete for just under a quarter of notifications (as discussed in the data quality section). In a recent example of how this impacts on the usefulness of the scheme, it was requested that the VHPSS investigate whether its data reflected a recent rise in community-acquired *Staphylococcus aureus* (*S. aureus*) cases, as this trend had been observed by another surveillance system. Because the admission date data were incomplete, almost 50% of records for this pathogen for the timeframe of interest had to be removed from the analysis. This limited the representativeness of the results of the analysis, and meant that the results could not be relied upon to support or deny the observed trend.

The VHPSS is also limited in its ability to monitor the emergence of important infections and related clusters, especially if these infections were to be predominantly hospital-acquired, as data is not received from three large tertiary hospitals, and the poor timeliness of data entry and analysis (as reflected in the scheme's performance against the KPI's) would limit the detection of clusters. As has been previously discussed, these factors also contribute to the probability that the VHPSS would be unable to detect and report an outbreak in a timely fashion.

The VHPSS is also not fulfilling its objective to report on the epidemiology of bloodstream and CSF infections to laboratory and clinical staff throughout Victoria, and has not fulfilled this objective since 2014. As discussed in the acceptability section, this

effects the perception of the value and usefulness of the VHPSS for both contributing and non-contributing laboratories, and it also likely contributes to the underutilisation of the scheme. Broad dissemination of quarterly reports not only to contributing laboratories, but also to any other stakeholders who may be interested in the content, and the publication of reports on an online and publicly accessible platform such as the MDU website, may act to increase awareness of the existence of the scheme and increase the utilisation of its data for public health research and action.

Consequently, the current performance of the VHPSS against its objectives and KPIs is significantly restricting its usefulness and utilisation. As discussed in the relevant sections of this evaluation, many of these performance issues can be remedied, but what form these remedies take will depend largely on what the future direction and purpose of the VHPSS is decided to be following this evaluation. An important consideration in informing this decision is how useful the VHPSS currently is in the context of other related surveillance systems, and whether the scheme is still capturing useful information that is not captured by other systems in Victoria.

Table 8 summarises the surveillance systems that are currently active in Victoria and nationally that overlap to varying degrees with the data collected by the VHPSS. As can be seen, many of these systems are targeted at specific organisms (AGAR, NEPSS, NNN, EIPDSWG, notifiable diseases surveillance), at infections in healthcare settings and from specific infection sites (VICNISS), or organisms with a specific antimicrobial resistance (CARAlert). As such, the VHPSS has the distinct advantage of being the only surveillance system that captures all bacterial and fungal organisms causing bloodstream or CSF infections, including any reported antimicrobial sensitivity results for these organisms. This effectively makes the VHPPS the only repository of information on those pathogens not specifically monitored by other schemes in Victoria, making it especially useful in events involving unusual pathogens (such as the aforementioned contamination events) and for monitoring the emergence of pathogens not yet considered important enough for targeted surveillance.

However, a consistent disadvantage of the VHPSS is its restriction to bloodstream and CSF infections. Many of the other systems, though restricted to certain organisms, monitor all laboratory-diagnosed infections, allowing them to gain a broader understanding of the burden and distribution of those diseases in the population, their

clinical manifestations, and their antimicrobial resistance patterns. Many of those systems restricted to specific organisms also receive enhanced clinical and/or epidemiological data, and receive data from all Victorian laboratories, making them more representative of the true number and distribution of cases in the population.

Summary

Overall, the VHPSS is a useful surveillance system. It collects information on invasive infections and antimicrobial sensitivities in pathogens not captured by any other surveillance system in Victoria, across both community and healthcare settings. However, the current performance of the VHPSS against its objectives and KPIs is significantly restricting its usefulness and utilisation. Various options exist to remedy the performance of the VHPSS, but should be considered in the context of the future direction and purpose of the VHPSS.

Table 8: Surveillance systems that overlap with the VHPSS and a comparison of data collected

Surveillance System	What it aims to capture	Overlap in data collection with the VHPSS	Captured by this system and not by the VHPSS	Captured by the VHPSS and not this system
Victorian Healthcare Associated Infection Surveillance System (VICNISS) Est. 2002[21]	• Hospital acquired infections and infections in admitted patients (which could be community acquired) • Participation in different surveillance 'modules' varies by hospital	• *Staphylococcus* aureus bloodstream infections from Victorian public hospitals • Any bloodstream or CSF infection from participating hospitals associated with: ○ Central line infections ○ Surgical site infections ○ Outpatient haemodialysis bloodstream infections ○ VRE and MRSA cases	• Notifications (for relevant modules) from the three hospital laboratories that do not contribute to the VHPSS • Enhanced clinical and hospitalisation data	• Community-acquired cases not attending a hospital • CSF infections • *Staphylococcus aureus* bloodstream infections from private hospitals • Any bloodstream or CSF infections that are missed by modules • Any bloodstream or CSF infections from hospitals that do not partake in that module
National Alert System for Critical Antimicrobial Resistances (CARAlert) Est. 2016[22]	Surveillance data on nationally agreed priority organisms with critical resistance to last-line antimicrobial agents	Bloodstream and CSF infections of these priority organisms and their antimicrobial resistance data	• National data • Notifications of these infections from the laboratories that do not contribute to the VHPSS • Non-invasive cases	• All other organisms • Notifications of bloodstream and CSF infections (and their AMR data) with these organisms that do not meet the CAR-alert definition
Australian Group on Antimicrobial Resistance (AGAR) Est. 1985[23]	Continuous antimicrobial resistance surveillance of priority organisms from blood cultures	All sample and AMR data for relevant bloodstream infections from laboratories that contribute to both systems	• National data • Notifications from some of the major hospital laboratories that do not contribute to the VHPSS	• CSF infections • Bloodstream infections of all other non-priority organisms • Notifications from the majority of private laboratories in Victoria that do not contribute to AGAR
Victorian notifiable diseases surveillance system/NNDSS Est.1917[5,6]	Notifiable diseases notifications	Bloodstream and CSF infections of notifiable diseases (*Salmonella*, Invasive Pneumococcal Disease etc.)	• Notifications from all laboratories and hospitals • Enhanced clinical and risk factor information (either from doctor notifications or through case follow-up)	• Antimicrobial resistance data (which is only collected/entered by the Victorian notifiable diseases system for certain conditions) • Bloodstream and CSF infections for all other non-notifiable pathogens

OrgTRx national expansion/ Australian Passive AMR Surveillance (APAS) Est. 2016[7]	Antimicrobial sensitivity and sample data for all public patient samples in Queensland. The recent expansion of this system captures this data from the laboratory that services Monash Health in Victoria (as well as selected labs in other states)	Antimicrobial sensitivities and sample data for all bloodstream and CSF infections from patients of Monash Health	• National data (from selected laboratories) • Non-invasive cases	• Data from all other Victorian contributing laboratories
National Neisseria Network (NNN) Est. 1979[24]	Conducts the Australian Gonococcal Surveillance Program (AGSP) and the Australian Meningococcal Surveillance Program (AMSP), which collect sample and AMR data for these infections	For Victoria this data comes from MDU, so all invasive cases identified by this system are duplicated in the VHPSS	• National data • Notifications from the laboratories that do not contribute to the VHPSS Non-invasive cases	• All other organisms • Any cases not sent to MDU for routine typing/AMR testing (uncommon)
National Enteric Pathogens Surveillance Scheme (NEPSS) Est. 1980[25]	Sample and AMR data from bacterial enteric human, animal, and food infections/contaminations	All human bacterial enteric infections and associated AMR data sent to MDU for isolation/typing from blood or CSF	• Some national data • Notifications from the laboratories that do not contribute to the VHPSS • Non-human isolates • Non-invasive cases	• All other organisms • Any cases not sent for routine typing/AMR testing (uncommon)
Enhanced Invasive Pneumococcal Disease Surveillance Working Group (EIPDSWG) Est. 2000[26]	Conducts Australia's Enhanced Invasive Pneumococcal Disease Surveillance Program which governs and collates enhanced data fields for notified cases of IPD in Australia	All cases of IPD isolated from bloodstream and CSF from laboratories that contribute to the VHPSS	• National data • Notifications from all laboratories and hospitals • Cases isolated from normally sterile sites other than blood and CSF • Enhanced clinical and risk factor information	• All other organisms

Conclusions and recommendations

Considering the findings of this evaluation, the VHPSS has been found to be a unique and useful surveillance system. It captures data on (typically) severe infections and their antimicrobial susceptibilities that are not captured by any other system; it is broadly representative of these infections in the Victorian population; and it has been running consistently for over 28 years, making it a valuable repository of information on pathogen and AMR trends over time. However, as detailed throughout this evaluation, a number of issues exist that hinder the effectiveness of the scheme and limit its usefulness in addressing immediate concerns especially. Options for addressing these issues have also been discussed throughout this evaluation, and while some are straightforward and can be relatively easily implemented, it will be most efficient to address many of these issues once the future purpose and direction of the VHPSS is considered and decided upon.

As a starting point, some potential options for the future development of the VHPSS and their impact on the scheme's usefulness have been listed below, ordered by the expected ease and cost of implementation. The viability of some of these options depends largely on the resources available to allocate to the scheme, but it is important to note that all options maintain the unique 'catch-all' element that makes the VHPSS so valuable.

Recommendations for the future development of the VHPSS

1. *Allow the VHPSS to continue functioning as it does currently*

The simplest and cheapest option, this would essentially constitute a decision to make the VHPSS solely a reference database that cannot be used for cluster/outbreak detection or for queries pertaining to immediate events. Ideally an electronic notification form would be developed (as this requires limited resources) to make contributing easier for laboratories, but whether resources should be allocated to re-instate regular reporting would need to be decided. Overall this option would likely decrease the usefulness of the VHPSS as it could not respond to urgent queries, nor would the data be regularly analysed and reported, which as discussed, would also lower the acceptability of the scheme for many stakeholders. This option is not recommended, as it does not address issues with the scheme that may threaten its future viability (such

as the acceptability of the scheme to contributors), and the functioning of the scheme could be greatly improved with a moderate allocation of funds.

2. *Restrict the scope of the scheme*

This option would constitute determining what data is actually used by the scheme and its stakeholders, and whether poorly reported variables (such as clinical information, hospital unit, and admission date) are worth capturing considering the burden they represent for some contributing laboratories. Removing admission date, for example, would have ramifications for the usefulness of the system in providing information on acquisition of infection (community or hospital) and associated trends in antimicrobial resistances. However, the current level of completeness for this variable already limits its usefulness, and it may be difficult for laboratories to increase the completeness of this variable. Advantages of restricting the scheme may be an increase in its acceptability to contributors (less time required to complete notifications), and a potential increase in timeliness of notification and data entry (less data to enter). A new notification form would still need to be developed, and the objectives and KPIs of the scheme amended. It is recommended that restricting the scope of the scheme be considered alongside improving the scheme, as dropping less useful variables and improving the completeness of others would result in the most efficient improvements.

3. *Improve the scheme in its current design*

In the short-term, this is the recommended option for improvement of the VHPSS, as although it will require more resources, it can be scaled depending on resource availability. Priority improvements would include developing an electronic notification form, moving VHPSS data to a new database and developing new user-interface programs, and allocating resources in the form of dedicated staff time to improving the timelines of data entry, analysis, and reporting. In addition to directly improving the relevant system attributes (timeliness, stability, flexibility, and simplicity), these improvements will also work to improve the acceptability of the scheme for stakeholders, and will make the scheme more useful as current data starts to be regularly reported.

Additional IT features, such as an algorithm to detect an exceedance of normal notification numbers, could also be developed to improve the detection of clusters and

make the scheme more useful in this respect. Further improvements could include attempting to improve data completeness, which may require resource support from the VHPSS if significant and time-consuming impediments exist for laboratories to provide this information, and investigating the development of direct electronic transfer of results. As discussed previously, were MDU able to resource the development of this system for each laboratory, it would greatly increase timeliness, data completeness, and the sensitivity of the scheme, as it would make contributing a possibility for the currently non-contributing laboratories. However, the cost to develop and maintain this system for each individual laboratory (each with their own different IT infrastructure) would be incredibly large, and would likely require additional external funding. To attract funding, the VHPSS would need to provide a strong argument for its increased usefulness, which might allow for the following development option.

4. *Increase the scope of the VHPSS*

Following the release of the Australian Government's First National Antimicrobial Resistance Strategy in June 2015,[10] The Australian Commission on Safety and Quality in Health Care began efforts to develop a national passive surveillance system for antimicrobial resistance across hospital, community and aged care settings; APAS.[7] As described on the Commission's website, the platform for this system is the OrgTRx program, which was developed by Pathology Queensland to electronically collect all public patient samples and their antimicrobial susceptibility data from laboratories across the state.[7] The program then produces a publicly accessible data cube which includes cumulative antibiograms for a range of organisms by specimen type, and tabulations showing the resistance profiles of organism strains. As shown in Table 8, this system is currently being expanded for national surveillance, starting in Victoria with the Monash Health laboratory.

Should the VHPSS receive funding to implement direct electronic transfer of results from all laboratories in Victoria, it is feasible that the scope of the VHPSS could be broadened to receive bacterial and fungal isolates from all infection sites and all associated antimicrobial susceptibility data. This would make the VHPSS the Victorian equivalent of OrgTRx, and would not only contribute to the planned expansion of national AMR surveillance, but would provide Victoria with its own centralized AMR surveillance system available for all research and public health action requirements. This system

would require substantial and ongoing external funding and would require multiple dedicated staff, but given that the VHPSS has close and long-held relationships with the majority of Victoria's diagnostic laboratories, this is not an entirely unrealistic possibility for the future development of the VHPSS.

Summary of recommendations

Table 9 provides a summary of the recommendations made throughout this evaluation for the improvement of the VHPSS. As discussed above, whether (and how) these are employed will depend on what the future purpose and direction of the VHPSS is decided to be.

Table 9: Summary of recommendations made and their expected outcomes

Recommendation	Expected outcome
• Review and amend as necessary the aim, objectives, and KPIs of the VHPSS in line with the decided future function of the scheme	• Create realistic benchmarks against which VHPSS performance can be measured and monitored
• Develop an electronic notification form (such as a fillable PDF) that can be completed and submitted either electronically or in hard copy	• Improve acceptability, simplicity, and timeliness of the notification process for contributing laboratories • Timeliness of data entry would increase with a decrease in time spent following up missing information and/or unclear handwriting
• Allocate adequate resources (in the form of staff time) to dedicated data entry, management, analysis and reporting. This may require the hiring of additional staff	• Would greatly improve the timeliness, acceptability, and usefulness of the scheme
• Re-instate regular quarterly reporting. Distribute these reports to all contributing laboratories individually and to any other potentially interested parties, and publish these reports on a publicly accessible platform	• Would greatly improve the data quality (regular cleaning), acceptability, and usefulness of the scheme • May encourage greater awareness and utilisation of the scheme
• Transfer the VHPSS data to a MySQL database in line with all other MDU databases, and create new fit-for-function user interface programs	• Would greatly improve the simplicity, flexibility, stability, and (potentially) timeliness of the scheme • Would facilitate any future technological improvements (including electronic transfer of results and automatic data entry) • Would increase the acceptability of the scheme for MDU/VHPSS staff
• Consider the value of poorly reported variables (including antimicrobial sensitivity results), and whether sustainable means can be developed to improve their completeness without burdening contributing laboratories	• Dropping poorly reported variables may increase the acceptability and timeliness of notifying for the contributing laboratories • Increasing the completeness of these variables may improve the usefulness of the VHPSS in being able to determine the place of acquisition of infections and possible trends or clusters in patient groups
• Consider the implications of encouraging all contributing laboratories to notify using their own laboratory result slips	• Increased timeliness of notification, data completeness, and reduced time spent following up missing or unclear data • Possible reduction in the completeness of antimicrobial sensitivity test results and clinical information
• Consider the financial and technical feasibility of establishing a system for direct electronic transfer of results for each laboratory in Victoria (and an associated online system that can ideally be used by stakeholders to interact with the data and generate their own reports)	• Would drastically improve the timeliness of data notification and entry • Would improve the acceptability of the scheme for contributing laboratories as the time-costs of notifying would be significantly reduced • May facilitate the participation in the scheme of currently non-contributing laboratories which would increase the sensitivity and representativeness of the scheme, and thus make the data more useful • May facilitate an increase in scope of the VHPSS to become a whole-of-state passive AMR surveillance system, increasing usefulness and utilisation

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Appendices

Appendix 1: VHPSS data collection form

VHPSS Blood Stream Infection & Meningitis Surveillance
In collaboration with the Victorian Advisory Committee on Infection Control (VACIC)

VHPSS No. (MDU Use Only)

Patient data

Name — Surname — Given
First 2 letters of: ☐☐ ☐☐

Date of Birth: __ / __ / ____ dd / mm / yyyy

Sex: (circle): F M

Residential Postcode: ☐☐☐☐

Specimen data

Laboratory Code:

Laboratory Specimen Number:

Specimen Type: (circle) Blood CSF

Date of specimen collection: __ / __ / ____ dd / mm / yyyy

Hospital data

Hospital Name/Code:

UR Number:

Date of Admission: __ / __ / ____ dd / mm / yyyy

Unit: (tick one only)

- ☐ Emergency
- ☐ Haematology/Oncology
- ☐ ICU - Adult
- ☐ ICU- Paediatric/Neonatal
- ☐ Internal Medicine
- ☐ Obstetrics/Gynaecology
- ☐ Outpatient/Not hospitalised
- ☐ Paediatrics/Neonatal
- ☐ Renal
- ☐ Surgery
- ☐ Urology
- ☐ Other (specify)

Underlying Clinical Condition:

Isolate data

Organism: (your identification)

Typing: (where applicable)

Is this isolate going to MDU? (circle) Yes No

(MDU use only)

MDU Sample ID

Genus/Species ☐☐☐☐ ☐☐☐☐

Qualifier ☐☐☐

Type1 Type2

ESBL mecA van

Date received: __ / __ / ____

Sensitivity data

Method: (circle) Disc diffusion Agar dilution Broth dilution E-test Vitek Microscan Other

[Fill in S (sensitive), I (intermediate), R (resistant) if drug was tested]

Antimicrobial	S, I, R	MIC* (mg/l)	Antimicrobial	S, I, R	MIC* (mg/l)	Antimicrobial	S, I, R	MIC* (mg/l)
Amikacin			Gentamicin			Tetracycline		
Ampicillin/Amoxicillin			Gentamicin high			Ticarcillin+Clavulanate		
Amoxicillin+Clavulanate			Imipenem			Trimethoprim		
Aztreonam			Linezolid			Tobramycin		
Cefazolin			Meropenem			Vancomycin		
Cefotaxime			Methicillin					
Ceftazidime			Metronidazole					
Ceftriaxone			Nitrofurantoin					
Cephalothin			Norfloxacin			Other antimicrobial 1		
Chloramphenicol			Oxacillin					
Ciprofloxacin			Penicillin			Other antimicrobial 2		
Clindamycin			Piperacillin					
Co-trimoxazole			Piperacillin+Tazobactam			Other antimicrobial 3		
Daptomycin			Rifampicin					
Erythromycin			Sulphonamide			ESBL present (circle)	Pos	Neg
Fusidic Acid			Teicoplanin			PCR MecA-gene (circle)	Pos	Neg

*MIC Method:(circle) Broth dilution Agar dilution E-test

Microbiological Diagnostic Unit Public Health Laboratory, Ph: (03) 8344 5701
E:\mdu_doc\FORMS\Request Forms_COC forms\FM108-3.0 (VHPSS Request Form).doc

Guidelines for completing the VHPSS form

Aims

The aim of the scheme is to monitor bacterial/fungal causes of bloodstream and CSF infections in Victoria by collecting, analysing and disseminating data from primary diagnostic laboratories on clinically significant isolates from human bloodstream and CSF specimens. In addition, the scheme aims to monitor antibiotic resistance in invasive pathogens and to actively enhance this surveillance in key pathogens from time to time.

When to complete this form

Please complete this form when you isolate bacteria or fungi from a blood or CSF specimen and there is microbiological and/or clinical evidence that the isolation represents a clinically significant infection. Do not complete the form when the isolate is clearly considered a contaminant organism. However, if there is uncertainty about the significance of a positive blood/CSF culture please complete a form. We are happy to receive reports of repeat isolations of the same species from the same patient on subsequent days. If your laboratory can automate the flagging of all positive blood/CSF cultures this will ensure high and consistent case ascertainment.

Episode definition

For the purposes of surveillance and analyses, an episode of bacteraemia or meningitis is defined as: the first isolation of a species of bacteria/fungi from a blood or CSF specimen from a patient within a 14 day period. Isolations of more than one different species of bacteria/fungi from the same patient irrespective of time period are counted as separate episodes (if deemed to be clinically significant).

Antimicrobial sensitivity data

Report sensitivities as resistant (R), intermediate (I) or sensitive (S) according to the testing method and guidelines used by your laboratory. Please report on all antimicrobials tested even if these were not reported to the requesting doctor. Please report the MIC (in mg/l) if this was performed. Report antifungal susceptibilities and any other antimicrobial not listed on the card in the space provided under "Other antimicrobial". Reporting sensitivities as less sensitive (LS), relatively resistant (RR) and sensitivity dose dependent (SDD) is acceptable for the following organisms: *N. meningitidis, S. pneumoniae* and yeasts. The presence of ESBL may be confirmed by testing a third generation cephalosporin in the presence of clavulanic acid or another beta-lactamase inhibitor. If your laboratory performs a PCR to detect mecA gene for *S. aureus* please report the PCR result.

Hospital Name/Code

Please report which hospital the patient was admitted to at time of specimen collection. Your laboratory may need to provide the VHPSS with a list of hospitals (and hospital codes) that your laboratory services.

Hospital Unit

Please indicate which hospital unit the patient was admitted to at the time of collection of the specimen. If the patient was not admitted at the time of collection please tick outpatient/not hospitalised. Provision of this data to VHPSS will mean that the scheme will be able to monitor trends in important pathogens by type of hospital unit.

Underlying Clinical Condition

Please report the principal underlying clinical condition(s) of the patient if this is known.

Date of Admission

Collection of date of admission is a key field. Date of admission is used as a marker of whether the infection is likely to be hospital or community acquired. Hospital acquired infections are those in which a bacterium/fungus was isolated 48 hours or more after the patient was admitted to hospital. Please provide the most recent date of admission that is relevant to the date of specimen collection.

Electronic/semi automated reporting

Some laboratories have implemented semi automated reporting to VHPSS. If your laboratory is interested in doing this please contact the VHPSS Co-ordinator.

Forwarding isolates to MDU Public Health Laboratory

MDU Public Health Laboratory offers a number of services for further phenotypic and genotypic identification of key pathogens. Please telephone the Director, Professor Ben Howden, to discuss these services. Ph: (03) 8344 5701/5713 or email: bhowden@unimelb.edu.au.

Please mail forms/specimens to Microbiological Diagnostic Unit Public Health Laboratory, Department of Microbiology & Immunology, The University of Melbourne, The Peter Doherty Institute for Infection and Immunity VIC 3010.

Direct deliveries can be made to 792 Elizabeth Street, Melbourne VIC 3000

Appendix 2: Contributing laboratory questionnaire

VHPSS Laboratory Survey 2016

The Victorian Hospital Pathogens Surveillance Scheme (VHPSS) invites you to participate in this questionnaire which will ask about your experience of contributing to the scheme, and how the scheme might be developed to better suit your needs. This questionnaire will take approximately 5-10 minutes to complete and is entirely voluntary.

If you wish for your responses to the questionnaire to be anonymous, please leave Question 1 blank.

Thank you for taking the time to complete this questionnaire.

SKIP LOGIC QUESTIONS HIGHLIGHTED

1. **What is the name of your laboratory?**

2. **Reporting to the VHPSS**

2.1. How do you provide data to the VHPSS?

- ☐ VHPSS card
- ☐ VHPSS card with attached Vitek report
- ☐ Direct copy of your result print-out
- ☐ Modified copy of your result print-out
- ☐ Other (please specify):

2.2. On average, how often do you batch reports to the VHPSS

- ☐ Daily
- ☐ Weekly
- ☐ Fortnightly
- ☐ Monthly
- ☐ Every two months
- ☐ More than every two months
- ☐ Other (please specify):

2.3. If your laboratory currently batches reports more than every two months, would it be feasible for your laboratory to increase the frequency of batching to *at least* every two months? If not, what problems/issues would prevent more frequent batching?

- ☐ Yes
- ☐ No (please specify why):

2.4. Who completes VHPSS reporting in your laboratory?

Number of staff:

Positions of staff:

2.5. On average, how many hours per week does reporting to the VHPSS usually require?

.....hours

2.6. Apart from staff time, are there any other resources your laboratory invests into participating in the VHPSS (e.g. IT resources)? If so, please list them.

- ☐ Yes (please specify resources):
- ☐ No

2.7. If you would like to comment further on the resources required to participate in the VHPSS, please do so below:

2.8. Do you currently report potential contaminants to the VHPSS (e.g. Coagulase-negative staphylococci without supporting clinical information)?

- ☐ Yes
- ☐ No
- ☐ Sometimes
- ☐ Don't know

2.9. Can you provide an estimate of the percentage of all eligible isolates identified (excluding contaminants) that are reported by your laboratory to the VHPSS for:

Blood isolates:

CSF isolates:

2.10. What antimicrobial sensitivity test results do you report to the VHPSS?

- ☐ All antimicrobial sensitivity tests results
- ☐ Just sensitivity test results thought to be relevant to the VHPSS
- ☐ Just sensitivity test results provided to clinicians
- ☐ Don't know

2.11. What are the problems/issues (if any) that limit the comprehensiveness of your isolate and/or antimicrobial sensitivity reporting?

2.12. Do you consider your current process of reporting to the VHPSS straightforward? If not, please briefly explain why.

- ☐ Yes
- ☐ No (please specify why):

3. Your experience of the VHPSS

3.1. Please give a brief description of what you understand the function of the VHPSS to be:

3.2. Have you ever requested information from the VHPSS, and if so, how frequently?

- ☐ Never
- ☐ Occasionally (ad hoc)
- ☐ Regularly (specific regular reports)
- ☐ Other (please specify):

3.3. What was this information used for (please select all that apply)?

- ☐ Clinical
- ☐ Reference
- ☐ Research
- ☐ General interest
- ☐ Other (please specify):

3.4. Did you find the information provided fulfilled your requirements?

- ☐ Yes
- ☐ No
- ☐ Don't know

3.5. Was the response from the VHPSS timely?

- ☐ Yes
- ☐ No
- ☐ Don't know

3.6. Apart from any requested reports, do you feel your laboratory receives adequate feedback (such as regular summary reports) from the VHPPS?

- ☐ Yes
- ☐ No
- ☐ Don't know

3.7. Have you found feedback informative and/or useful? If not, could you please briefly state why.

- ☐ Yes
- ☐ No (please specify why):

3.8. Overall, do you consider your laboratory's participation in the VHPSS to be worthwhile? Please provide a brief comment on why or why not.

4. Your input on the VHPSS

4.1. Reporting to the VHPSS

We would like to make reporting to the VHPSS easier and more efficient for contributing laboratories. We would like your opinions on how you would prefer to report and why.

4.1.1. Is there a way in which your laboratory would prefer to report to the VHPSS? Please select all that apply:

- ☐ Result print-outs with attached Vitek reports
- ☐ Direct faxing of result print-outs and Vitek reports
- ☐ Electronic transfer of results spreadsheet (e.g. by email or upload to a web page)
- ☐ Electronic VHPSS notification form that can be completed and submitted either electronically or in hardcopy

- ☐ No, current process is preferred
- ☐ Other (please specify):

4.1.2. Why would you prefer to use this new method (please select all that apply)?

- ☐ It would be easier
- ☐ It would be less time consuming
- ☐ It would be easier to teach to new staff
- ☐ More people in the laboratory would be able to use this method
- ☐ It would be in line with methods used to report to other systems
- ☐ Other (please specify):

4.2. Reports *from* the VHPSS

The frequency and content of reports produced by the VHPSS for contributing laboratories is currently being reviewed. We would like your opinions on what you would find most useful.

4.2.1. Please provide a brief description of the sort of information and analyses you would like to receive from the VHPSS:

4.2.2. How often would you like this feedback to be sent?

- ☐ Monthly
- ☐ Quarterly
- ☐ Six-monthly
- ☐ Yearly
- ☐ Other (please specify):

4.2.3. How would you prefer to receive these reports? Please select all that apply:

- ☐ Hard-copy (post)
- ☐ Email
- ☐ Link to a website publication
- ☐ Other (please specify):

5. **If you have any further comments or suggestions about the current and/or future functioning of the VHPSS you would like to add, please do so below:**

Thank you again for taking the time to complete this questionnaire. Your participation is greatly appreciated and will contribute to the improvement of the VHPSS.

Appendix 3: Questions sent to non-contributing laboratories

Dear

The Victorian Hospital Pathogen Surveillance Scheme (VHPSS) is a voluntary, laboratory-based surveillance scheme of bacterial and fungal causes of blood stream infections (BSI) and meningitis in the Victorian population that has been running continuously since 1988. Notifications to the VHPSS include information on patient demographics, relevant clinical information, basic hospital admission details (where relevant), and organism identity and reported antimicrobial sensitivities. The VHPSS database now contains over 25 years of information on bloodstream/meningitis infections and their antimicrobial sensitivities, representing a range of both community and healthcare associated infections. For notifiable conditions such as invasive pneumococcal disease where isolates are routinely referred to MDU PHL, notifications to the VHPSS represent 100% of cases in Victoria, but for other infections it has previously been estimated that approximately 60-80% of all eligible Victorian blood culture and cerebrospinal (CSF) isolates are reported.

Our records show that your laboratory does not currently contribute to the VHPSS. In an effort to improve both the representativeness of the scheme and the notification process for contributing laboratories, we would like to ask a few short questions about why your laboratory does not contribute, and whether your laboratory would consider contributing in the future. This will help us to better understand and address the barriers to participation in the scheme, and perhaps make participation a viable possibility for your laboratory. This survey should not take more than 10 minutes of your time and would provide valuable information for the improvement of scheme for future public health action. Your participation would be greatly appreciated.

Question 1. Were you previously aware of the VHPSS and the types of information it collects?

Question 2. If you were previously aware of the VHPSS, could you please state why your laboratory does not contribute to the scheme?

Question 3. Contributing laboratories currently submit notifications to the VHPSS via a hardcopy VHPSS form or by sending laboratory test results and antimicrobial sensitivity reports. We are currently working to develop a simpler and more accessible

form of electronic reporting. Are there any particular ways in which the VHPSS could improve the process of notification that would make participating in the scheme possible for your laboratory?

Question 4. Do you have any other suggestions or comments as to how the VHPSS could be developed to facilitate your participation in the scheme?

Thank you for taking the time to complete this survey, your participation is greatly appreciated. Should you be interested in participating in the VHPSS or have any other questions about the scheme please call Janet Strachan on 03 ---- ----.

Thank you.

With kind regards,

Professor Benjamin Howden

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Appendix 1:
Summary of Teaching Activities

First-year Cohort Teaching Exercise

and

Lesson from the Field

Teaching requirements and activities

As the ability to teach public health concepts and to engage in peer to peer learning are important activities for public health professionals and field epidemiologists, there are two teaching requirements included in the MAE program. Each MAE candidate must:

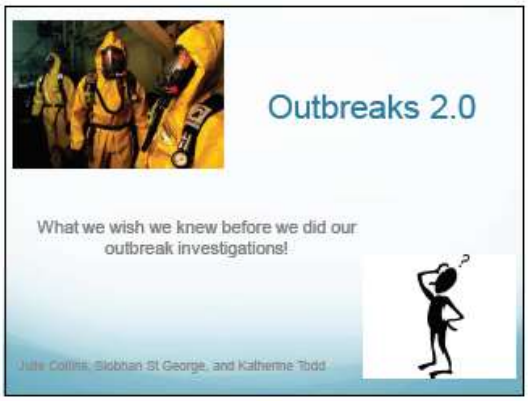
- Prepare and conduct a lesson for first year MAE students (or another epidemiology training program), as part the second year subject POPH8914 Issues in Applied Epidemiology
- Prepare at least one (and participate in all) “Lessons from the field”

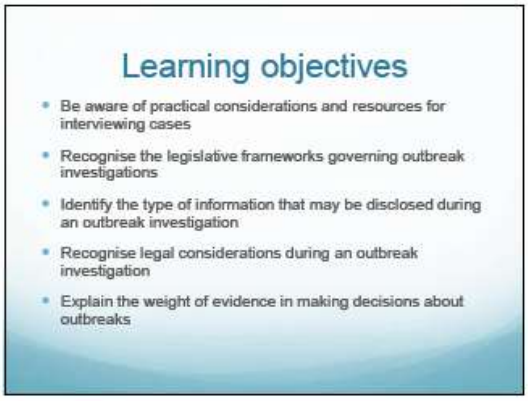
First-year cohort teaching exercise

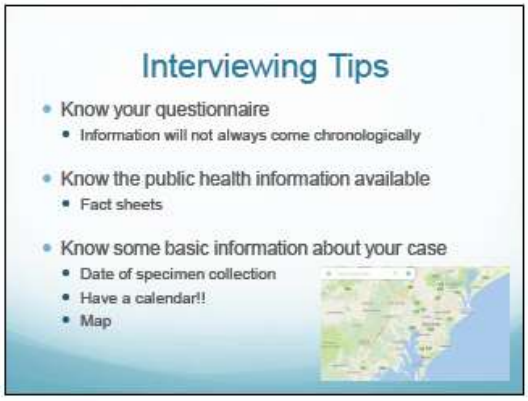
At the end of the third course-block (March 2017), the second-year MAE cohort was given an afternoon session (from approximately 1:30-5:00pm) in which to teach the first-year cohort. It was decided within our cohort that our lesson would consist of a series of presentations on subjects we thought would be helpful to the first-years, and a fun trivia contest to allow the two cohorts to get to know each other better.

My contribution to the lesson was to put together an “Outbreaks 2.0: What we wish we knew before we did our outbreak investigations” presentation, in collaboration with my fellow cohort members Julie Collins and Katherine Todd, who also worked extensively with OzFoodNet in their placements. The aim of this lecture was to provide the first-year cohort with some practical advice for undertaking outbreak investigations that we thought it would have been helpful to know before undertaking our own investigations. The feedback provided by the first-year cohort on our lesson was that it was very interesting and would be helpful in preparing them for their investigations. The slides for our presentation are provided below.

Figure 1: First-year teaching exercise presentation slides







How should you organise information?

- Questionnaires often paper based / online word
- Enter into a database asap to allow for ongoing analysis
  - Epi Info
  - Excel or Access (if systematic) – Stata
- Keep all information until the investigation is over
  - Don't throw out your questionnaires!

Resources

Resources

Resources

Legislation

- Each state and territory has legislation pertaining to the follow-up/investigation of cases of diseases of public health importance
- This legislation is different in each state
- Usually the Acts particularly relevant to investig outbreaks are Food Acts and Public Health Wellbeing) Acts

Legislation

- It is important to know what legislation you are working under and what it says so that you can refer back to it
- People often want to know what right you have to collect information, and what right they have to give it

This commonly happens with:

- Receptionists at GP clinics*
- Nurses*
- Hospitals*
- Less familiar GPs*
- Businesses (e.g. booking information)

*Especially when seeking consent to contact

Legislation - examples

Victoria

Public Health and Wellbeing Act 2008, Part 9 Division 1

187 Power to request information

(1) An authorised officer may request a person to provide information to the authorised officer which the authorised officer believes is necessary to investigate whether there is a risk to public health or to manage or control a risk to public health.

(2) A person is authorised to provide the information requested under subsection (1).

Note

See section 227.

(3) A person may refuse to provide the information requested under subsection (1).

Public Health and Wellbeing Act 2008, Part 11 Division 4

227 Protection of person giving certain information

The giving of information that is authorised or required to be given under this Act in accordance with this Act—

(a) does not for any purpose constitute unprofessional conduct or a breach of professional ethics on the part of the person by whom it is given; or

(b) does not make the person by whom it is given subject to any liability in respect of it; or

(c) does not constitute a contravention of any other Act or law (including common law).

Legislation - examples

Queensland

Foodborne disease investigation lies under the *Food Act 2006*

Chapter 7, Part 2, Division 7

202 Power to require information

1) This section applies if an authorised person reasonably believes

(a) an offence against this Act has been committed; and

(b) a person may be able to give information about the offence.

(2) The authorised person may, by notice given to the person,

require the person to give information about the offence to the authorised person at a stated reasonable time and place.

(3) The person must comply with a requirement under subsection (2), unless the person has a reasonable excuse.

(4) It is a reasonable excuse for an individual to fail to give information if giving the information might tend to incriminate the individual.

Other investigations fall under different acts including the *Public Health Act 2005*

Chapter 3, Part 3, Division 2

99 Power to require contact information

1) This section applies if a contact tracing officer—

(a) reasonably suspects that a person—

(i) has a notifiable condition; or

has, (ii) has been in contact with person who or may have, a notifiable condition; and

(b) has explained to the person that information is needed to attempt to prevent or minimise the spread of the notifiable condition.

(2) The contact tracing officer may ask the person to give the contact tracing officer all or any of the following information(the contact information) within a stated time...

Providing information

- At some point during your investigation you may be asked questions like What happened? How did I get sick? Are there others? What will happen now?
- It's sometimes hard to 'walk the line' between providing information and saying something you shouldn't (or even knowing what that is!)
- Some say 'it's safest to say nothing at all'
- I feel we have a duty, and a fantastic opportunity, to increase knowledge and awareness in people who are often our target audience!
- But we have to be aware of the possible legal implications of what we say (Katherine to speak more about this)

Things you usually can and can't say

(again, check with your PHOs, this may change depending on where you are)

Can (and arguably should!)

- Information about the person you are speaking to e.g. typing results
- Information about the pathogen e.g. where it originates and how contamination commonly occurs
- Potential sources of infection/risk factors depending on survey responses but only AFTER the interview (bias)
- Unspecific information about investigation processes*
- What will happen with their information and what action will be taken
- Education about other relevant risks and how to avoid them

Official information request processes

*ALWAYS REMEMBER TO INCLUDE CAVEATS

Can't

- Any absolutes – we can almost never definitively say anything is the case, just that the evidence indicates 'it'
- Other people's personal and illness information
- Other people's specific test results
- Number of cases**
- Suspected sources of infection (when source not clear)**
- Results of the environmental investigation**
- Legal advice
- Anything to the media!

**Providing this information before the investigation is completed can be misleading or even incorrect!

Requests for Information

- If someone wants access to the full outbreak report and other relevant documents (e.g. for legal action) they often need to submit an official request for information, such as a Freedom of Information (FOI) request (VIC) or a request under the Government Information (Public Access) Act 2009 (NSW)
- There is usually a fee ($30-50) and requests are commonly submitted online
- Links to the appropriate forms should be available on your state health department's website

What are the legal implications of outbreak investigations?

- You may become involved in civil, criminal or coronial proceedings
- Your investigation report, draft reports, copies of letters, emails and other communications may be subpoenaed and tendered in court.
- You may be required to be attend court as a witness
- Your investigation report or how you conducted the investigation may be under review

Example 1: Civil action

Court tips a bucket on KFC: $8m payout to girl paralysed by poison chicken

Example 2: Coronial inquest

- "[the lawyer for the family]… submitted that had the epidemiological investigation proceeded with greater haste during the previous week (had, for example, the questionnaire been developed within an hour or two, and the interviews with parents occurred on the 16 or 17 January instead of the 18th, 19th and 20th), the conclusion that Garibaldi garlic mettwurst was involved could have been reached at a much earlier stage…"

Example 3: Criminal prosecution

28 years for salmonella: Peanut exec gets groundbreaking sentence

Unanderra Betta Maid boss Udo Boschan to pay $15K in court costs

What happens if we get it wrong?

Example 4: California strawberries and cyclosporiasis

- "Announcements implicating California strawberries as the source of the cyclosporiasis outbreaks in May of 1996 had a devastating effect on the strawberry industry
- Supermarket chains took California strawberries off their shelves… Consumers stopped buying strawberries from all sources. Truckloads of strawberries headed for market rotted as they were turned away
- Strawberry sales around the United States and Canada crashed, causing $40 million in losses for the industry and the loss of 5,000 jobs"

Heavy stuff!

- So how do we make decisions when the evidence is unclear? When do we decide we have enough evidence?

So how do we decide?

- You must balance the potential public health impact of a problem with the known quality of available data and the potential damage to business or industry
- Information that might lead officials into taking action when data are suggestive of the source but insufficient to make a definitive call include:
  - The severity of the disease
  - The population at risk
  - Whether exposure is suspected to still be occurring
  - The quality of available data
  - Potential impact on business/industry

Key take-home points

1. Remember that sometimes action is taken on epidemiological evidence alone
2. You will constantly be balancing the need to take public health action with creating a critical level of evidence to support taking that action
3. In an outbreak setting the pressure to take action can be intense
4. Document, document, document!
5. Keep your documents organised
6. When decisions are being made, share your opinion – it is ok to have a robust discussion!
7. Your best protection is good teamwork

Lesson from the field

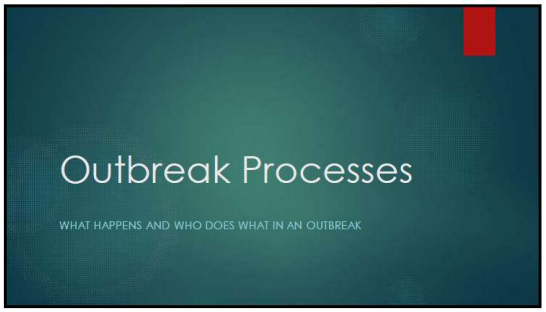
The Lessons from the Field (LFF) teaching requirement is designed to maximise opportunities for peer-to-peer teaching and learning by presenting 'real-life' challenges and experiences faced by students in the field. As my field placements were with OzFoodNet Victoria and the Microbiological Diagnostic Unit Public Health Laboratory, I was heavily involved in the surveillance and investigation of foodborne diseases and outbreaks. I felt the LFF provided a great opportunity to share the in-depth knowledge I had gained in foodborne disease epidemiology and surveillance with my peers, some of whom were working in very different environments and might not otherwise attain this knowledge through their MAE.

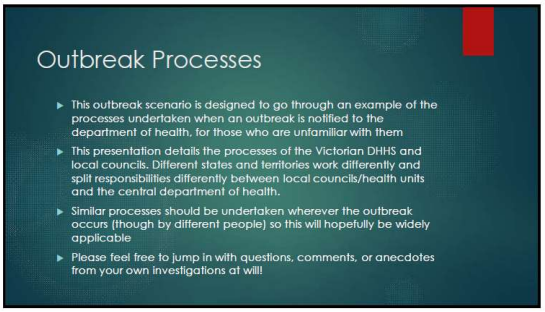
The primary objective of my LFF was for participants to gain a more thorough understanding of foodborne disease surveillance and outbreak investigation processes. Taking a lesson from the highly successful trivia quiz run as part of the first-year cohort teaching exercise described above, I also wanted to incorporate some 'fun' learning tools to break up to format of the LFF and to make the session more interesting for my peers. As such, in addition to the presentation I prepared on outbreak investigation processes (Figure 2), I also prepared a Foodborne and Enteric Diseases crossword puzzle (Figure 3), and a Kahoot! quiz.

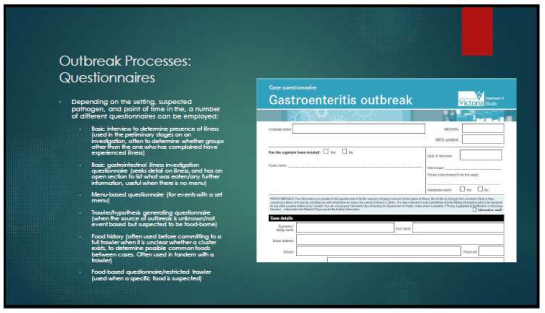
Kahoot! is a free online game platform where users can create multiple choice quizzes. Players then access the Kahoot! website or mobile application, enter a unique game ID, and can then play against each other to answer the timed quiz questions. Players receive more points the faster they answer a question. This quiz provided a great format for my LFF group to test their enteric disease knowledge and to learn new things when we discussed the correct answers. Figure 4 shows the layout of the quiz for players, who must select the shape/colour that corresponds to the correct answer. Figure 5 lists the questions included in my Kahoot! quiz and their answers.

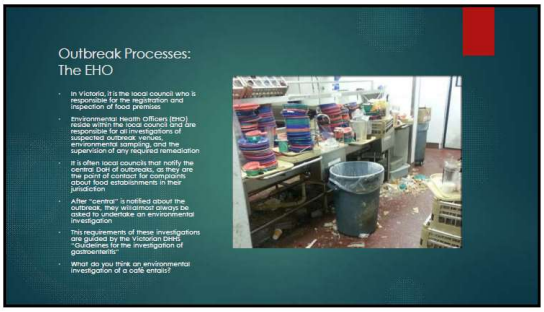
The feedback from my LFF group was that the session was informative and fun, and that it facilitated peer-to-peer sharing and discussion, achieving its purpose and objective.

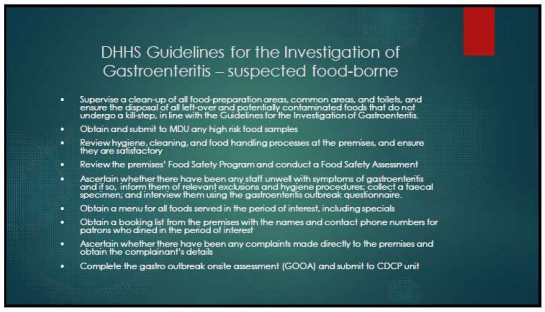
Figure 2: LFF Outbreak Processes presentation

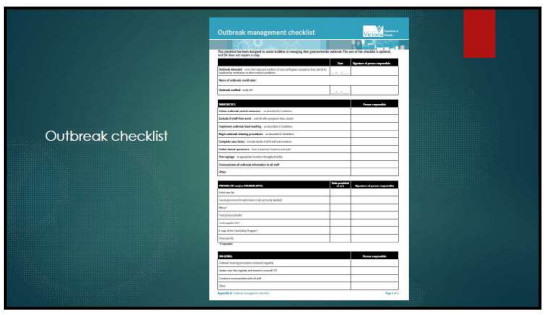


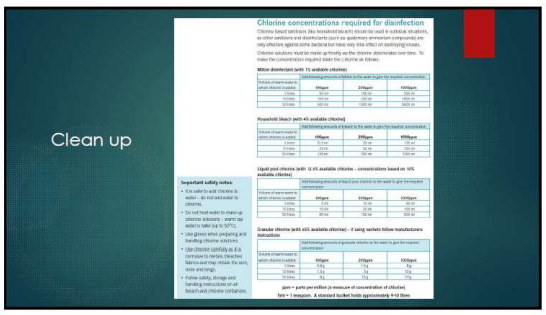


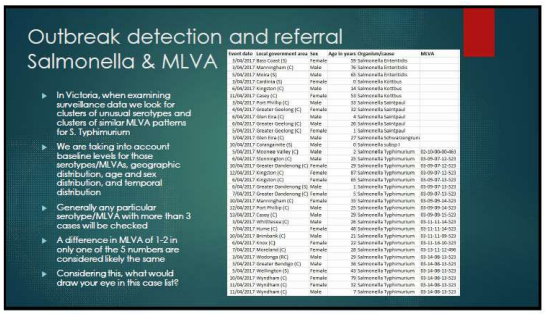






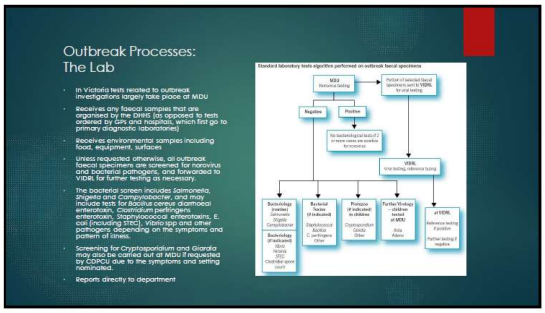






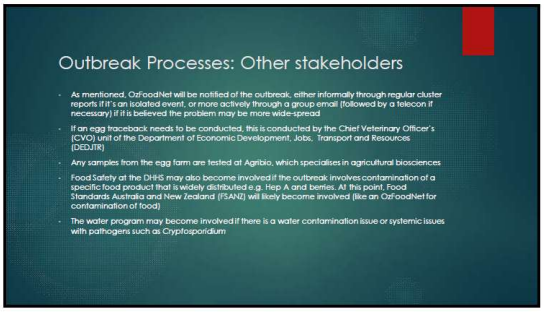
- We refer cases under six months to the local council for investigation. Why, do you think?
- We keep an eye on Saintpaul, and might want to investigate a geographic/temporal cluster
- There are two MLVA types in next group, but with only one difference at one point, so likely represent the same infection. Also geographically clustered, and some quite close in time
- The last MLVA we will say, for the sake of this exercise, is quite common in Victoria, but we might want to keep an eye out for more Wyndham cases, especially as they are also close in time

Onset date	Local government area	Sex	Age in yea	Organism/Cause	MLVA
1/04/2017	East Coast (S)	Female	69	Salmonella Enteritidis	
1/04/2017	Mannyngham (C)	Male	76	Salmonella Enteritidis	
1/04/2017	Mona (S)	Male	65	Salmonella Enteritidis	
3/04/2017	Cardinia (S)	Female	0	Salmonella Kottbus	
4/04/2017	Kingston (C)	Male	14	Salmonella Kottbus	
11/04/2017	Casey (C)	Female	55	Salmonella Kottbus	
1/04/2017	Port Phillip (C)	Male	55	Salmonella Saintpaul	
1/04/2017	Greater Dandenong (C)	Female	57	Salmonella Saintpaul	
6/04/2017	Glen Eira (C)	Male	6	Salmonella Saintpaul	
6/04/2017	Greater Geelong (C)	Male	29	Salmonella Saintpaul	
5/04/2017	Greater Geelong (C)	Female	1	Salmonella Saintpaul	
1/04/2017	Glen Eira (C)	Male	27	Salmonella Schwarzengrund	
16/04/2017	Corangamite (S)	Male	0	Salmonella subsp I	
5/04/2017	Moonee Valley (C)	Male	2	Salmonella Typhimurium	30-13-09-39-865
4/04/2017	Stonnington (C)	Male	25	Salmonella Typhimurium	33-39-07-12-522
10/04/2017	Greater Dandenong (C)	Female	29	Salmonella Typhimurium	33-39-07-12-522
11/04/2017	Kingston (C)	Female	87	Salmonella Typhimurium	33-39-07-12-522
4/04/2017	Kingston (C)	Female	65	Salmonella Typhimurium	33-39-07-12-522
6/04/2017	Greater Dandenong (C)	Male	1	Salmonella Typhimurium	33-39-07-12-522
7/04/2017	Greater Dandenong (C)	Female	1	Salmonella Typhimurium	33-39-07-12-522
28/04/2017	Mannyngham (C)	Female	25	Salmonella Typhimurium	33-39-09-14-522
22/04/2017	Port Phillip (C)	Male	25	Salmonella Typhimurium	33-39-09-14-522
23/04/2017	Casey (C)	Male	29	Salmonella Typhimurium	33-39-09-15-522
1/04/2017	Whittlesea (C)	Male	20	Salmonella Typhimurium	33-11-11-14-522
7/04/2017	Hume (C)	Female	48	Salmonella Typhimurium	33-11-11-14-523
16/04/2017	Brimbank (C)	Male	71	Salmonella Typhimurium	33-11-11-09-523
6/04/2017	Knox (C)	Female	22	Salmonella Typhimurium	33-11-10-10-523
7/04/2017	Moreland (C)	Female	28	Salmonella Typhimurium	33-13-11-12-496
1/04/2017	Wodonga (RC)	Male	29	Salmonella Typhimurium	33-14-09-13-523
1/04/2017	Greater Bendigo (C)	Male	36	Salmonella Typhimurium	33-14-09-13-523
5/04/2017	Wellington (S)	Female	46	Salmonella Typhimurium	36-14-06-16-526
10/04/2017	Wyndham (C)	Female	74	Salmonella Typhimurium	36-14-06-16-526
11/04/2017	Wyndham (C)	Female	62	Salmonella Typhimurium	36-14-06-16-526
11/04/2017	Wyndham (C)	Male	7	Salmonella Typhimurium	36-14-06-16-526



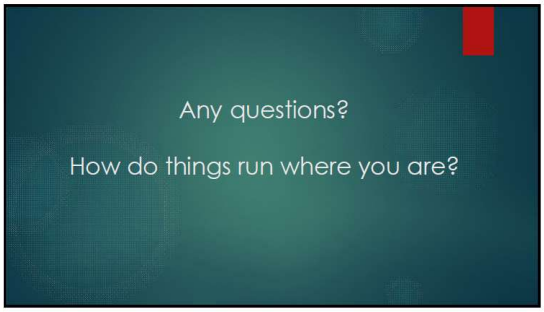
Outbreak Processes: The Lab

- In Victoria tests related to outbreak investigations largely take place at MDU
- Receives any faecal samples that are organised by the DHHS (as opposed to tests ordered by GPs and hospitals, which first go to primary diagnostic laboratories)
- Receives environmental samples including food, equipment, surfaces
- Unless requested otherwise, all outbreak faecal specimens are screened for norovirus and bacterial pathogens, and forwarded to VIDRL for further testing as necessary.
- The bacterial screen includes *Salmonella*, *Shigella* and *Campylobacter*, and may include tests for *Bacillus cereus* diarrhoeal enterotoxin, *Clostridium perfringens* enterotoxin, Staphylococcal enterotoxins, *E. coli* (including STEC), *Vibrio* spp and other pathogens depending on the symptoms and pattern of illness.
- Screening for *Cryptosporidium* and *Giardia* may also be carried out at MDU if requested by CDPCU due to the symptoms and setting nominated.
- Reports directly to department



Outbreak Processes: Other stakeholders

- As mentioned, OzFoodNet will be notified of the outbreak, either informally through regular cluster reports if it's an isolated event, or more actively through a group email (followed by a telecon if necessary) if it is believed the problem may be more wide-spread
- If an egg traceback needs to be conducted, this is conducted by the Chief Veterinary Officer's (CVO) unit of the Department of Economic Development, Jobs, Transport and Resources (DEDJTR)
- Any samples from the egg farm are tested at Agribio, which specialises in agricultural biosciences
- Food Safety at the DHHS may also become involved if the outbreak involves contamination of a specific food product that is widely distributed e.g. Hep A and berries. At this point, Food Standards Australia and New Zealand (FSANZ) will likely become involved (like an OzFoodNet for contamination of food)
- The water program may become involved if there is a water contamination issue or systemic issues with pathogens such as *Cryptosporidium*

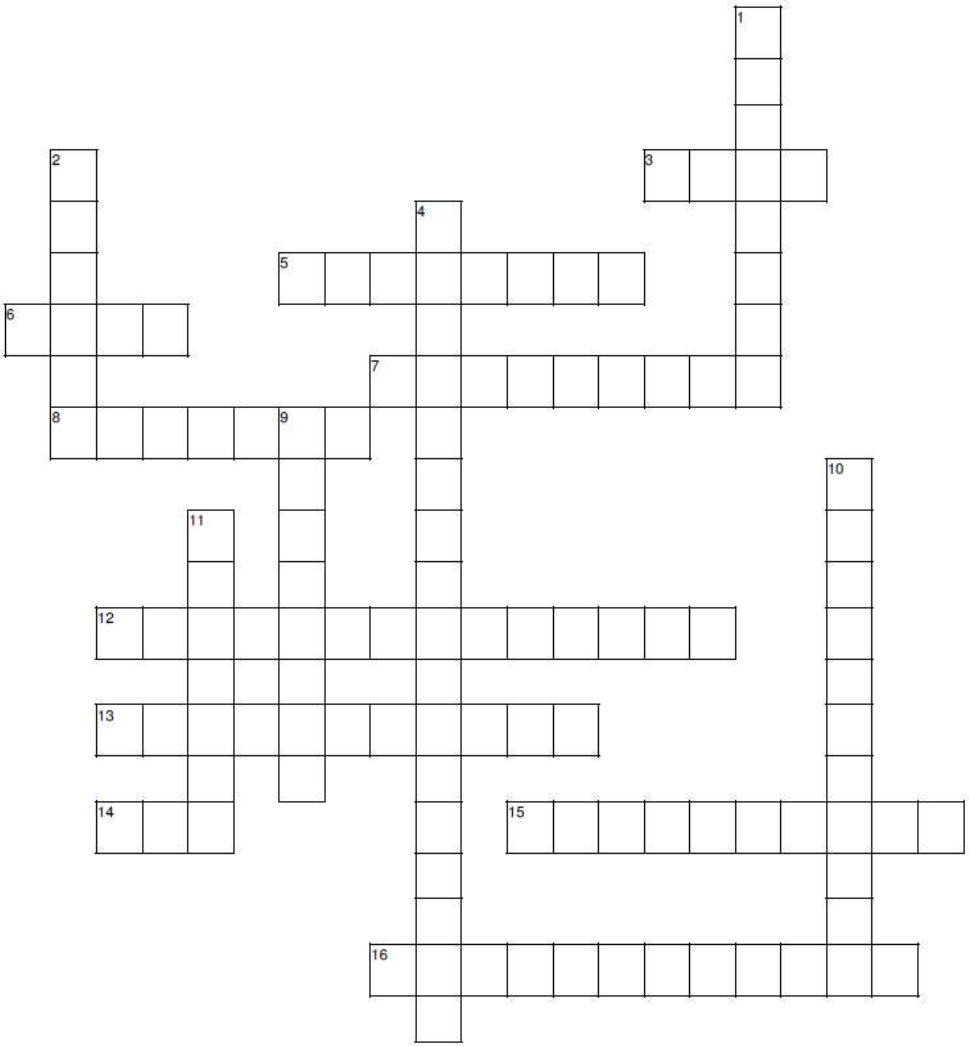


Any questions?

How do things run where you are?

Figure 3: LFF Foodborne and Enteric Diseases crossword puzzle

Foodborne and Enteric Disease Fun Times!



Across

3. The maximum number of hours a freshly produced potentially hazardous food can be held in the temperature 'danger zone' (5-60 degrees celcius)

5. Food-borne disease that is commonly associated with canned foods

6. The molecular technique commonly used to characterise Salmonella Typhimurium isolates

7. The genome against which others is compared is called the ... genome

8. What is the 'noro' in norovirus short for?

12. viruses used to characterise Salmonellae in the process of phage typing

13. The Salmonella serovar commonly associated with Tasmania

14. Syndrome associated with STEC/VTEC infection

15. The period between infection and presentation of symptoms

16. The P in SNP stands for Single Nucleotide...

Down

1. conditions which are the consequence of a previous disease or injury

2. The surname of Typhoid Mary

4. The process required to kill Cryptosporidium in a pool

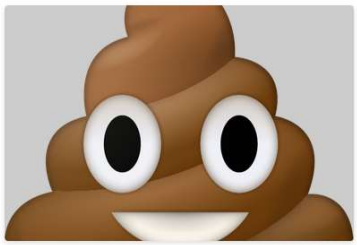
9. Food-borne disease that is commonly associated with deli meats and soft cheeses

10. The Salmonella serovar notorious for being able to enter the egg before laying

11. The infective stage/form of the Cryptosporidium parasite

Figure 4: Kahoot! Quiz player layout

Figure 5: Full list of Kahoot! Quiz questions and answers. The correct answer/s are marked with a tick.



Enteric and Foodborne Disease LFF

A private quiz for university

A quiz about enteric and foodborne diseases

4 plays 0 favorites

ChevvySG
Created 4 months ago

Questions (16) Hide all answers

30 sec

Q1: Test Question (no points): Who is the MAE course convener?

John Snow | Katrina Roper | Martyn Kirk ✓ | Typhoid Mary

30 sec

Q2: What is the most commonly notified food-borne pathogen in Australia?

Salmonella ✓ | *Campylobacter* ✓ | Norovirus | *Shigella*

30 sec

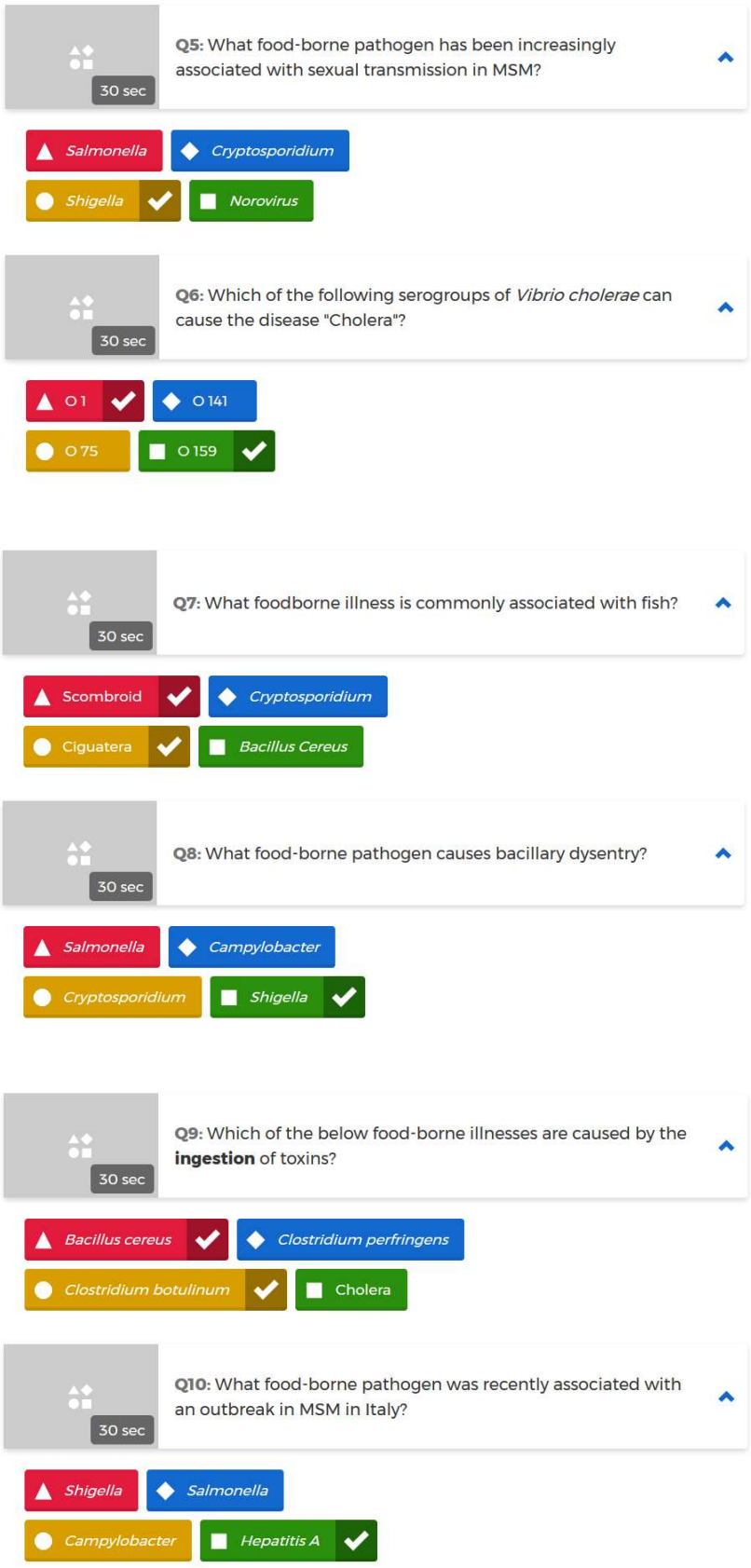
Q3: In which state or territory is *Campylobacter* currently not notifiable?

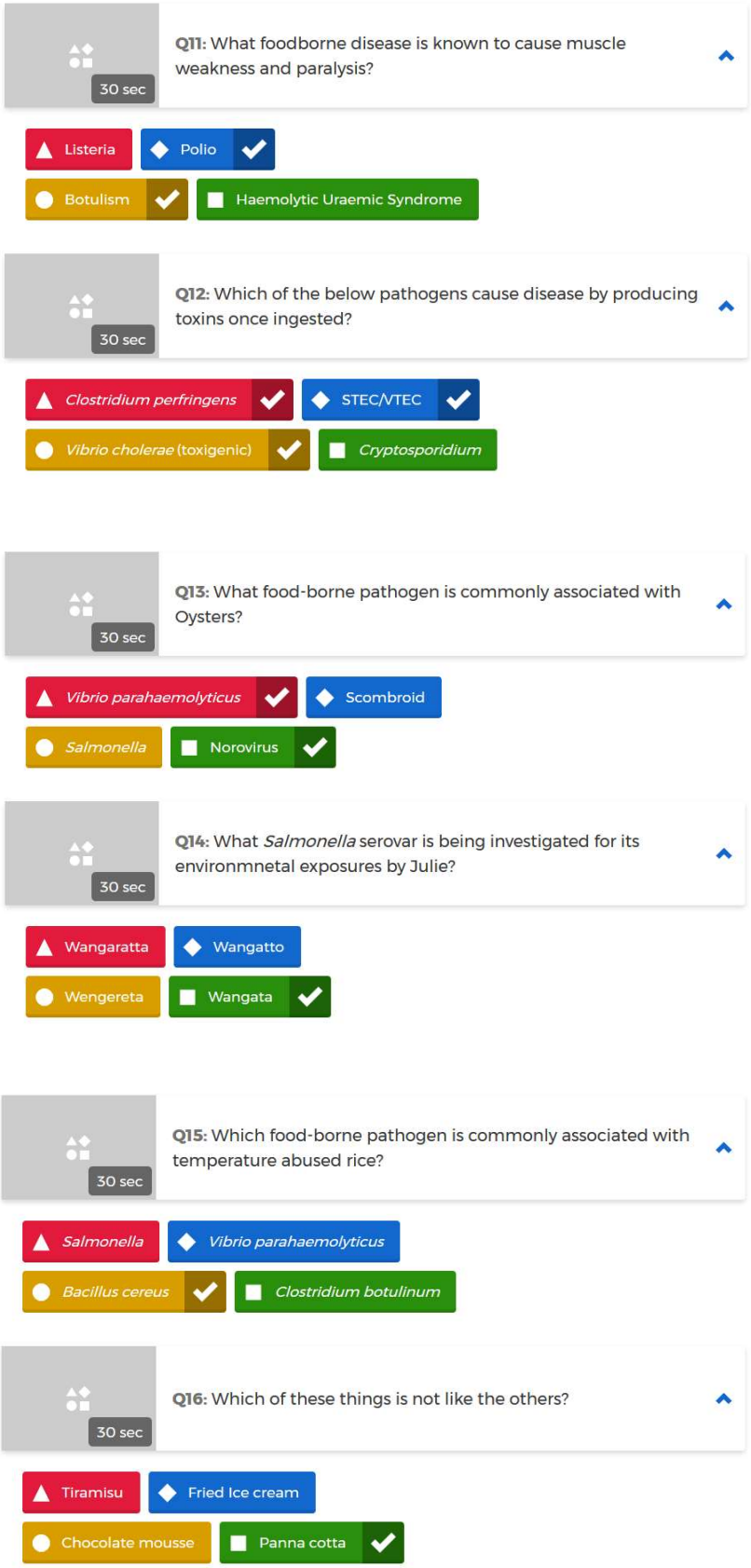
Victoria | New South Wales ✓ | Tasmania | Queensland

30 sec

Q4: What serotype of *Salmonella* is most commonly notified in Australia

Typhimurium ✓ | Enteritidis | Hvittingfoss | St Paul


30 sec
Q5: What food-borne pathogen has been increasingly associated with sexual transmission in MSM?
Salmonella
Cryptosporidium
Shigella
Norovirus
30 sec
Q6: Which of the following serogroups of Vibrio cholerae can cause the disease "Cholera"?
O 1
O 141
O 75
O 159
30 sec
Q7: What foodborne illness is commonly associated with fish?
Scombroid
Cryptosporidium
Ciguatera
Bacillus Cereus
30 sec
Q8: What food-borne pathogen causes bacillary dysentry?
Salmonella
Campylobacter
Cryptosporidium
Shigella
30 sec
Q9: Which of the below food-borne illnesses are caused by the ingestion of toxins?
Bacillus cereus
Clostridium perfringens
Clostridium botulinum
Cholera
30 sec
Q10: What food-borne pathogen was recently associated with an outbreak in MSM in Italy?
Shigella
Salmonella
Campylobacter
Hepatitis A


30 sec
Q11: What foodborne disease is known to cause muscle weakness and paralysis?
Listeria
Polio
Botulism
Haemolytic Uraemic Syndrome
30 sec
Q12: Which of the below pathogens cause disease by producing toxins once ingested?
Clostridium perfringens
STEC/VTEC
Vibrio cholerae (toxigenic)
Cryptosporidium
30 sec
Q13: What food-borne pathogen is commonly associated with Oysters?
Vibrio parahaemolyticus
Scombroid
Salmonella
Norovirus
30 sec
Q14: What Salmonella serovar is being investigated for its environmnetal exposures by Julie?
Wangaratta
Wangatto
Wengereta
Wangata
30 sec
Q15: Which food-borne pathogen is commonly associated with temperature abused rice?
Salmonella
Vibrio parahaemolyticus
Bacillus cereus
Clostridium botulinum
30 sec
Q16: Which of these things is not like the others?
Tiramisu
Fried Ice cream
Chocolate mousse
Panna cotta