Applied Epidemiology in the Hunter New England and Western Pacific regions

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Field Placement

OzFoodNet, Hunter New England Population Health

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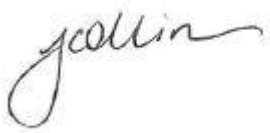
Originality statement

I hereby declare that this submission is my own work and 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 Australian National University or any other educational institution, except where due acknowledgment is made in the thesis. Any contribution made to the research by others 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.

Signed: 

Date: 8 November 2017

Acknowledgements

I have met and been encouraged by many people throughout the Master of Philosophy (Applied Epidemiology) program and would like to acknowledge those who have been a part of this experience.

Foremost, I would like to thank my field supervisor, James Flint, for sharing his knowledge with me over the last two years. James, your enthusiasm for public health and international development and your willingness to tackle complex and challenging problems is inspiring. I am grateful for your unfailing patience and sound advice throughout my MAE journey.

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I am very grateful to have been a part of the Health Protection Unit at Hunter New England Population Health. I was privileged to be surrounded by experienced and discerning public health experts, with Tony Merritt just a doorway away and ever happy to listen to my questions and provide sound advice. Thank you, in particular, to David Durrheim for your inspiring leadership and unwavering support. I enjoyed working with each of the service teams, but a special mention to Philippe Porigneaux and the Environmental Health team – thank you for taking me in and getting excited about *Salmonella* with me. Lastly, but importantly, thank you to Kim Lilly, Kat Taylor and Belinda Jones for being my daily source of support and advice as we contemplated public health problems over afternoon coffee – thank you for your friendship and personal support.

To my fellow MAE cohort, it has been wonderful to go through the program with you. Thank you for providing a constant source of humour to keep the stressful times at bay and for always giving sound epidemiological advice. I value the friendships that we have made and look forward to seeing where your careers in epidemiology take you.

Thank you in particular to my fellow MAE enteric colleagues, Siobhan St George, Katherine Todd and (honorary) Rosemary Wright. Thank you for making enterics fun and for being there on the other end of the teleconference – it was great to know that we were working together to solve outbreaks.

To my family, thank you for your steadfast support throughout this journey – no matter where in the world it took me. To my friends – in particular Jill and Mel – thank you for your understanding when I buried myself in books again and for being the first to explain to people what an epidemiologist does!

To all those I have listed and to those I have missed, I would like to express my gratitude – thank you.

Abstract

In this thesis, I present work conducted as a Master of Philosophy (Applied Epidemiology) (MAE) Scholar based at the OzFoodNet sentinel site at Hunter New England Population Health. During my placement, I was involved in a number of public health investigations both locally and in the Western Pacific region. The MAE core competency requirements and the epidemiological skills that I developed through my field placement are demonstrated in the following chapters.

I was fortunate to be at the coalface of public health in my placement at the Local Health District and was able to be involved in a number of outbreak investigations. I led an investigation of an outbreak of *Campylobacter* in a rural community in New South Wales. This investigation included a retrospective cohort study with the aim of characterising cases and identifying the source of infection to prevent further illness. Data were collected on food and animal exposures prior to the first onset of illness in the community. We found no statistically significant food exposures, however this was complicated by near universal exposure to some food items. A review of cooking processes identified undercooked chicken as the likely source of infection in this outbreak. I was also involved in local outbreaks of gastroenteritis associated with a primary school and a *Salmonella* Typhimurium outbreak associated with a restaurant. In addition, I was involved in an investigation of paediatric severe acute respiratory infections requiring admission to intensive care units as a part of a World Health Organization deployment to Fiji in May 2016.

I conducted an epidemiological project examining environmental risk factors for human infection with *Salmonella* serovar Wangata in north east New South Wales. I designed and administered a case-control study in three Local Health Districts. Data on environmental exposures were collected for cases and two separate control groups: cases of *Salmonella* Typhimurium and community controls from the neighbourhood of cases. This project included a large data analysis component, with separate multivariable logistic regression models developed to analyse environmental exposures in each control group. Whole genome sequencing was used to examine the relatedness between human isolates and environmental specimens collected as a part of this project.

During my deployment to Fiji in May 2016, I was involved in the surveillance of infectious diseases following Tropical Cyclone Winston. I co-evaluated the Early Warning Alert and Response System (EWARS in a Box) with fellow MAE Scholar, Meru Sheel. Nine syndromes were reported to the EWARS system from 34 sentinel sites in Fiji. The web based EWARS system utilised smartphone reporting and was considered simple, acceptable and generally useful for users. Recommendations were made to improve the

layout and interpretation of surveillance reports and to enhance operating procedures and guidelines for surveillance officers. This was the first time the EWARS in a Box system had been implemented in a Pacific Island Country and the experiences of the system in Fiji can be used to assist other countries in the region who are experiencing humanitarian disasters.

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Chapter 1 - Introduction

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Abbreviations

ART	Acute Response Team
ERL	Enteric Reference Laboratory
FCCDC	Fiji Centre for Communicable Disease Control
FETPNG	Field Epidemiology Training Programme in Papua New Guinea
FSANZ	Food Standards Australia and New Zealand
GOARN	Global Outbreak Alert and Response Network
HNE	Hunter New England
HNELHD	Hunter New England Local Health District
HPU	Health Protection Unit
LHD	Local Health District
MAE	Master of Philosophy (Applied Epidemiology)
MDR-TB	Multi-drug-resistant tuberculosis
NSW	New South Wales
NSWFA	New South Wales Food Authority
OFN	OzFoodNet
PHU	Public Health Unit
PNG	Papua New Guinea
SARI	Severe acute respiratory infections
STEC	Shiga toxin-producing *Escherichia coli*
TEPHINET	Training Programs in Epidemiology and Public Health Interventions Network
WHO	World Health Organization
WHO DPS	World Health Organization Division of Pacific Technical Support

1.1 Overview of field placement and public health experience

I had a diverse range of experiences in the Master of Philosophy (Applied Epidemiology) (MAE) program and was fortunate to be able to 'get my hands dirty' and apply epidemiological concepts in a number of field settings, from interviewing cases of foodborne illness at the Public Health Unit (PHU), to testing environmental sampling protocols on the north coast of NSW, to reviewing hospital registers in northern Fiji, to mentoring field epidemiology students in Papua New Guinea.

1.1.1 OzFoodNet

My field placement was with the OzFoodNet sentinel site at Hunter New England Population Health. OzFoodNet is a network of epidemiologists in each state and territory in Australia who focus on foodborne illness. A coordinating epidemiologist is based at the Office of Health Protection at the Department of Health, Canberra. New South Wales (NSW) has two OzFoodNet sites: one at Health Protection NSW in North Sydney and one at Hunter New England Population Health in Newcastle.

The OzFoodNet network is a model of information sharing and collaboration. I was privileged to be able to participate in monthly teleconferences and attend tri-annual face-to-face meetings. I also gave a presentation at the face-to-face meeting in Brisbane, March 2017 on the *Salmonella* Wangata project that I was leading. The OzFoodNet network conducts surveillance of foodborne pathogens and is regularly involved in outbreak response activities due to the incidence of foodborne illness in Australia. I participated in weekly monitoring teleconferences with the NSW Health Protection OzFoodNet team, the NSW Enteric Reference Laboratory (ERL) and the New South Wales Food Authority (NSWFA). I was involved in interviewing patients for a number of state-based foodborne outbreaks. I was also fortunate to be involved in multi-jurisdictional outbreak investigations of *Salmonella* Saintpaul and *Salmonella* Hvittingfoss during my placement. Multi-jurisdictional outbreak investigations involve multiple states and territories and include collaborating bodies such as Food Standards Australia and New Zealand (FSANZ). These experiences gave me practical insights into the complexity of outbreak responses across multiple jurisdictions and the competing priorities of collecting sufficient evidence and implementing timely control measures.

1.1.2 Hunter New England Population Health

The OzFoodNet sentinel site sits within the Health Protection Unit (HPU) at Hunter New England Population Health and consists of Coordinating Epidemiologist, James Flint, and Research Officer, Kim Lilly. The HPU, led by Director David Durrheim, is comprised

of five service teams. The teams include: Communicable Diseases, Environmental Health, Immunisation, Biopreparedness and OzFoodNet. Collectively, these teams make up the Acute Response Team (ART). The ART responds to public health emergencies within the Hunter New England region and meets on a weekly basis to conduct monitoring and plan response activities. I was privileged to participate in ART meetings and have exposure to a diverse range of public health problems, from communicable disease outbreaks, to zoonotic diseases, to environmental health threats. I was also given the opportunity to support other team activities. For example, in April 2017 I was fortunate to be involved in a local cruise ship inspection with the HNE Environmental Health team. This was a valuable experience and helped me to better understand the interaction between state public health legislation and international maritime conventions.

As a part of the OzFoodNet team, I was involved in a number of local outbreak response activities. Some outbreak investigations were initiated by identifying signals in surveillance data, whilst others were initiated after receiving notifications from the community or the NSWFA. In April 2017, we were notified by a medical practitioner of an outbreak of *Campylobacter* in a rural, intentional community in NSW. I was nominated to lead this outbreak investigation, under the guidance of HNE public health physicians, and was fortunate to be able to go onsite to meet with the community. This was a great experience that taught me to balance community and public health expectations. I was also involved in local outbreaks of *Salmonella* and norovirus, and followed up notifications of enteric diseases such as Shiga toxin-producing *Escherichia coli* (STEC) and *Shigella*.

Hunter New England Population Health has a particular interest in One Health and zoonotic diseases. I was given the opportunity to lead an investigation into suspected environmental sources and risk factors for infection with *Salmonella* serovar Wangata during my placement. This was a wonderfully collaborative project that allowed me to work with veterinary, laboratory, environmental health and public health colleagues. I presented preliminary results from this project at the Communicable Diseases Conference in Melbourne, June 2017.

Hunter New England Local Health District (HNELHD) has its own governing body but sits within the NSW Ministry of Health network. As such, I was able to be involved in both local and state-wide public health activities. In June 2017, I participated in a state-wide influenza pandemic exercise (PaNCIMS) as a Situation Report Officer in the Planning Team for HNELHD. This was a great experience in biopreparedness and planning for public health emergencies.

1.1.3 Field experiences in the Western Pacific region

The Health Protection Unit at Hunter New England Population Health has a strong connection to the Western Pacific region. Director David Durrheim has served on expert advisory groups to the World Health Organization (WHO) in the region and a number of team members have been involved in research, collaboration and training activities. My supervisor, James Flint, is involved in facilitating the Field Epidemiology Training Programme in Papua New Guinea (FETPNG), an activity which I also supported in my placement. I contributed to five face-to-face training phases in Papua New Guinea (PNG) covering two FETPNG cohorts during my MAE placement. In between training phases, I also provided one-to-one mentoring support for fellows whilst they conducted their field projects. The saying 'there is no better way to learn than to teach' (Benjamin Whichcote) encapsulates this experience. As a FETPNG faculty member, I was exposed to a diverse range of public health problems, from establishing diabetes surveillance, to maternal health and unsupervised deliveries, to multi-drug-resistant tuberculosis (MDR-TB), to neglected tropical diseases such as yaws. Working with the fellows, I was challenged to apply simple epidemiological concepts that would be effective in low-resource settings. The field projects undertaken as a part of the program have had a large impact on public health in PNG and have been recognised by provincial and national health authorities. Four fellows also presented at the 9th Global TEPHINET Conference in Chiang Mai, Thailand in August 2017 where I was privileged to support them.

Early in my placement, I was given the opportunity to undertake a WHO secondment in Fiji under the Global Outbreak Alert and Response Network (GOARN). I worked with the WHO Division of Pacific Technical Support (WHO DPS) and the Fiji Centre for Communicable Disease Control (FCCDC) over a four-week period in May 2016 to conduct disease surveillance following Tropical Cyclone Winston, which devastated parts of the country in February 2016. Along with fellow MAE Scholar, Meru Sheel, I evaluated the sentinel, syndromic surveillance system that had been implemented post Cyclone Winston (EWARS in a Box). This was a fantastic experience that introduced me to the benefits and limitations of syndromic surveillance. As a part of surveillance activities during this secondment, I was involved in a national outbreak investigation into a suspected increase of paediatric severe acute respiratory infections (SARI). Along with a FCCDC counterpart, I was involved in data collection for the investigation in the Northern Division of Fiji. I was also nominated to lead a publication on the outbreak investigation and presented this work at the 9th Global TEPHINET Conference in Chiang Mai, Thailand in August 2017.

1.2 Master of Philosophy (Applied Epidemiology) core competency requirements

Field Projects

Investigate an acute public health problem	Outbreak of *Campylobacter* in a rural community in New South Wales, March–April 2017 (Chapter 2) An outbreak of gastroenteritis in a primary school in the Hunter New England Local Health District (Chapter 3) Outbreak investigation of *Salmonella* Typhimurium MLVA -11-15-10-523 associated with a restaurant in the Hunter New England Local Health District (Chapter 3) Investigation of paediatric severe acute respiratory infections (SARI) in Fiji (Chapter 3)
Analyse a public health dataset	Identifying the sources of *Salmonella enterica* serovar Wangata infections in north east New South Wales: A combined epidemiological and molecular approach (Chapter 4)
Design and conduct an epidemiological study	Identifying the sources of *Salmonella enterica* serovar Wangata infections in north east New South Wales: A combined epidemiological and molecular approach (Chapter 4)
Evaluate a surveillance system	Early Warning Alert and Response System (EWARS in a Box) post Tropical Cyclone Winston, Fiji, 2016 (Chapter 5)

Additional requirements

Literature review	A review of the literature was conducted for each of the field projects listed above. An example literature review is provided in Chapter 4, Appendix 4.2
Summary for a lay audience	Infection control factsheet for food premises affected by a norovirus outbreak (Chapter 3, Appendix 3.3)
Publication	**Collins J,** Biaukula V, Faktaufon D *et al*. **An outbreak investigation of paediatric severe acute respiratory infections requiring admission to intensive care units – Fiji, May 2016.** Western Pacific Surveillance and Response Journal. 2018 June; 9(2). doi: 10.5365/wpsar.2017.8.4.009 (Chapter 3, Appendix 3.1)

Oral conference presentation	**Collins J**, Bell G, Durrheim D, Hill-Cawthorne G, Hope K, Howard P, Kohlenberg T, Lawrence K, Lilly K, Mor S, Porigneaux P, Simpson K, Sintchenko V, Ward M, Wiethoelter A, Flint J. **Environmental risk factors for *Salmonella* serovar Wangata in north east NSW**. Presented at the Communicable Diseases Conference, Melbourne, 27 June 2017. (Chapter 4, Appendix 4.3) **Collins J**, Biaukula V, Faktaufon D, Flint J, Fullman S, Jalava K, Kailawadoko J, Merianos A, Nilles E, Roper K, Sheel M, Kama M. **An outbreak investigation of paediatric severe acute respiratory infections (SARI) requiring admission to intensive care units, Fiji, May 2016**. Poster presentation orally presented at the 9th Global TEPHINET Conference, Chiang Mai, Thailand, 7–11 August 2017. (Chapter 3, Appendix 3.2)

Teaching

Teaching of Field Epidemiology Fellows in Papua New Guinea	Summary of teaching experience provided in Chapter 6
Lesson from the field	**Collins J**. **Using online questionnaires for outbreak investigations**. Conducted via teleconference, 15 June 2017. (Chapter 6, Appendices 6.3 & 6.4).
Teaching first year MAE cohort	**Collins J**, St George S, Todd K. **Outbreaks 2.0**. Presented at MAE Courseblock March 2017. (Chapter 6, Appendix 6.5)

Coursework

POPH8916 Outbreak investigation	✓
POPH8917 Public health surveillance	✓
POPH8913 Analysis of public health data	✓
POPH8915 Methods in Applied Epidemiological Research	✓
POPH8914 Issues in Applied Epidemiology	✓

1.3 MAE core competency matrix

MAE Competency	Chapter 2 Outbreak of *Campylobacter*	Chapter 3 Other Public Health Investigations	Chapter 4 Identifying the sources of *Salmonella* Wangata	Chapter 5 Evaluation of EWARS in a Box (Fiji)	Chapter 6 Teaching
Investigate an acute public health problem	✓	✓			
Analyse a public health dataset			✓		
Design and conduct an epidemiological study			✓		
Evaluate a surveillance system				✓	
Literature review			✓		
Summary for lay audience		✓			
Publication		✓			
Oral presentation		✓	✓		
Lesson from the field					✓
Lesson for 1st year MAE cohort					✓

Chapter 2 - Outbreak Investigation

Outbreak of *Campylobacter* in a rural community in New South Wales, March–April 2017

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Abbreviations

AR	Attack rate
CI	Confidence interval
HNELHD	Hunter New England Local Health District
HPU	Health Protection Unit
NSW	New South Wales
NSWFA	New South Wales Food Authority
OFN	OzFoodNet
PHU	Public Health Unit
RR	Relative risk

2.1 Prologue

2.1.1 My role

The Hunter New England OzFoodNet (OFN) team are primarily responsible for the investigation of possible foodborne outbreaks within the Hunter New England Local Health District (HNELHD). Under the guidance of public health physicians at the Public Health Unit (PHU), I led an investigation to try and identify the source of an outbreak of *Campylobacter* in a rural community. With support from public health physicians, Tony Merritt and Kat Taylor, I undertook a number of tasks including: liaising with the community representative, developing a questionnaire, conducting case interviews, data entry and data analysis, as well as disseminating findings to the Hunter New England Health Protection team, the New South Wales (NSW) Ministry of Health and to the community itself. As a part of this investigation, I conducted a site visit with Kat Taylor to gain a better understanding of the community's water supply and cooking processes, as well as to conduct initial interviews with community members.

2.1.2 Lessons learnt

This was a very interesting outbreak investigation that posed some epidemiological challenges due to the homogeneity of exposures within the community. I particularly appreciated the opportunity to visit the community in-person and gain a better understanding of the context and processes within which the outbreak occurred. This outbreak investigation provided a valuable experience in balancing the needs and expectations of public health agencies with those of community members.

2.1.3 Public health impact

This outbreak had a large impact on the community both in terms of illness and time off work. We determined that there was no ongoing risk to the community at the time of the investigation as the suspected food item had been disposed of and there had been no new cases. The onsite visit and ongoing communication with the community was important in raising awareness about possible transmission pathways for infection with *Campylobacter* for the prevention of future outbreaks.

Private community settings are not regulated under the Food Act 2003 (NSW), however food handlers still have a duty of care to maintain due diligence in relation to food safety. We raised awareness of food safety measures with the community and offered support from the New South Wales Food Authority (NSWFA) for further upskilling. The frequent contamination of raw poultry products with *Campylobacter* in Australia presents an

ongoing risk for potential outbreaks. Thus, it is important to maintain ongoing education on food safety for those involved in the cooking and preparation of poultry products.

2.1.4 Acknowledgements

I would like to acknowledge the Hunter New England Health Protection team and the Enteric and Zoonotic Diseases team at the NSW Ministry of Health for their assistance during this investigation.

In particular, I would like to thank Tony Merritt and Kat Taylor for their tireless support and guidance throughout the investigation. I would like to thank Kim Lilly and Belinda Jones for their assistance in data management. I would also like to thank my supervisor, James Flint, for his ongoing support and assistance with the analysis of this outbreak.

2.1.5 Master of Philosophy (Applied Epidemiology) core activity requirements

This chapter meets the following core activity requirement:

- Investigation of an acute public health problem

2.2 Abstract

Introduction

In April 2017, the Hunter New England Public Health Unit (PHU) was notified of a suspected outbreak of *Campylobacter* in a rural, intentional community in New South Wales. An investigation was initiated to characterise the cases, identify the potential source of infection and implement appropriate control and prevention measures.

Methods

A retrospective cohort study was undertaken in the community. A combination of face-to-face interviews and paper-based questionnaires were used to collect information on illness and exposures. Exposures were analysed for statistical association with illness by calculating relative risks, 95% confidence intervals and *p* values. Dose-response relationships for chicken consumption and illness were also examined by calculating relative risks and using a linear test for trend. Public health staff obtained details on food handling practices, communal water sources and agricultural exposures as a part of the environmental investigation.

Results

Data were obtained for 76 of 101 residents (75%), with 20 persons meeting the case definition. Four of five stool specimens submitted by cases were positive for *Campylobacter*. Agricultural and water exposures were determined to be unlikely sources of infection based on the level of exposure and the distribution of cases. Univariable analyses did not identify a particular food item as being statistically associated with illness. The comparison of food consumption between those who were ill and those who were not ill was complicated by almost universal exposure to some food items. A review of cooking processes identified possibly undercooked chicken as the likely source of infection.

Conclusion

Undercooked chicken was the suspected vehicle of infection in this outbreak. The frequent contamination of raw poultry with *Campylobacter* in Australia is a risk for potential outbreaks. Ongoing food safety education for community settings, particularly in relation to the cooking of poultry, is an important preventative public health measure.

2.3 Introduction

Campylobacter is the most frequently notified bacterial cause of gastrointestinal illness in Australia, with health authorities receiving 19,931 notifications in 2014.[1] Prior to April 2017, confirmed *Campylobacter* infections were not required to be notified to health authorities in New South Wales (NSW), except in situations where they were suspected to be linked to an outbreak (Two or more cases related by time or place or cases in an institution).[2,3] Outbreaks of *Campylobacter* in NSW have previously been linked to undercooked chicken liver pâté, duck liver parfait and cross-contamination with raw chicken.[4-7]

Symptoms of *Campylobacter* typically include diarrhoea, abdominal pain, fever, malaise, nausea and in some cases vomiting.[8] Approximately 10% of outbreak-associated cases have reported bloody diarrhoea in Australia.[9] The incubation period for *Campylobacter* is generally 2–5 days, but can range from 1–10 days following exposure.[8] Illness is generally self-limited, although *Campylobacter* has been associated with sequelae such as irritable bowel syndrome, reactive arthritis and conditions such as Crohn's disease and ulcerative colitis.[10,11]

On 4 April 2017, a medical practitioner notified the Hunter New England Public Health Unit (PHU) of a number of cases of gastrointestinal illness in a rural community in NSW. A community representative reported that approximately 40% (53/120) of community members had fallen ill with gastrointestinal symptoms after 28 March 2017. One community member had a positive stool specimen for *Campylobacter*. An investigation was initiated with the aim of characterising cases and identifying the source of infection in order to inform control measures and prevent future occurrences.

2.4 Methods

2.4.1 Outbreak setting

The outbreak occurred in a rural, intentional community in NSW. Intentional communities are planned residential communities designed to have a high degree of social cohesion. Members typically hold a common social, political or religious view and may follow an alternative lifestyle. Intentional communities may vary in their level of interaction with outsiders. In outbreak investigations, it may be difficult to understand transmission pathways in intentional communities due to their communal nature and seemingly homogenous exposures among residents.

The community in which this outbreak occurred contains 12 multi-occupancy dwellings housing approximately 120 people and operates on a model of self-sufficiency, with onsite agricultural production contributing a large proportion of foods consumed. Drinking water is provided via a number of separate rainwater tanks located throughout the community. Residents attend communal lunch meals in the community dining hall during the week, as well as a communal evening meal on Saturdays. Nursery-aged children (<6 years) do not attend the communal meals but have a meal provided separately.

2.4.2 Epidemiological investigation

A retrospective cohort study was conducted with members of the community following an onsite visit by public health staff on 6–7 April 2017. A self-administered questionnaire **(Appendix 2.1)** was developed and piloted face-to-face with approximately 20 community members on 6 April 2017 (sampled using convenience methods). Pilot interviews implicated the communal meals as the likely site of a point source exposure. Nursery-aged children (<6 years) did not attend communal meals in the community dining hall and did not report any illness. Children aged less than six years were given separately prepared and separately served meals at the nursery (or daycare) under the supervision of selected community members. As parents did not supervise their children at these meals, information on the foods consumed by each child was unable to be obtained and therefore children aged less than 6 years (n=19) were excluded from the retrospective cohort study.

The questionnaire was distributed to community members (n=101) via a representative, along with a letter explaining the purpose of the investigation. Completed questionnaires were scanned and sent to public health staff on 10 April 2017. We collected information on demographics, symptom profile, illness onset and duration, contact with animals and foods consumed at communal meals in the 5 days prior to, and including, the date of suspected first onset. The date of suspected first onset (28 March 2017), was provided by the onsite community nurse prior to the investigation. Place of residence was also obtained to determine the proximity of cases and possible secondary transmission.

2.4.3 Case definitions

A case was defined as a resident or visitor of the community who attended communal meals* and reported an onset of an acute diarrhoeal illness (three or more loose stools in a 24-hour period) on or after 28 March 2017.

**Nursery-aged children (<6 years) did not attend communal meals and were excluded from the retrospective cohort study.*

2.4.4 Data analysis

Data were entered into a REDCap (Research Electronic Data Capture) database and analysed using Excel 2013 (Microsoft Corporation, USA), Stata version 14.1 (StataCorp LP, College Station, TX, USA) and OpenEpi Version 3.01 (Open Source Epidemiologic Statistics for Public Health, www.OpenEpi.com). Relative risks (RR), Fisher Exact 95% confidence intervals (CI) and *p* values were calculated to quantify the association between exposure variables and illness. Where a cell contained a zero value, 0.5 was added to all cells in order to approximate the relative risk.[12,13] Dose-response relationships for chicken consumption and illness were examined by calculating relative risks for each level of exposure, compared to a reference group (lowest exposure level).[14] In addition, dose-response was examined using the Mantel-Haenszel chi-squared test for linear trend. Spot maps were used to illustrate the distribution of cases and identify possible routes of transmission. Spot maps were created using PowerPoint 2013 (Microsoft Corporation, USA).

2.4.5 Environmental investigation

Public health staff explored a range of possible environmental and zoonotic sources as a part of the investigation. Details were obtained on food handling practices, communal water sources and agricultural exposures. There were no left-over food products available for testing. Environmental samples were not collected as a part of the investigation.

Public health investigations of foodborne illness in NSW often involve environmental inspections by local councils under the authority of the NSWFA. However, the production of food within in the community was not deemed to meet the definition of 'food for sale' under the *Food Safety Act 2003 (NSW)* and therefore the NSWFA did not have jurisdiction to conduct an inspection of the premises.

2.4.6 Microbiological investigation

Stool specimens were collected by a local medical practitioner and tested for a range of enteric pathogens using culture and antigen tests.

2.5 Results

2.5.1 Epidemiological investigation

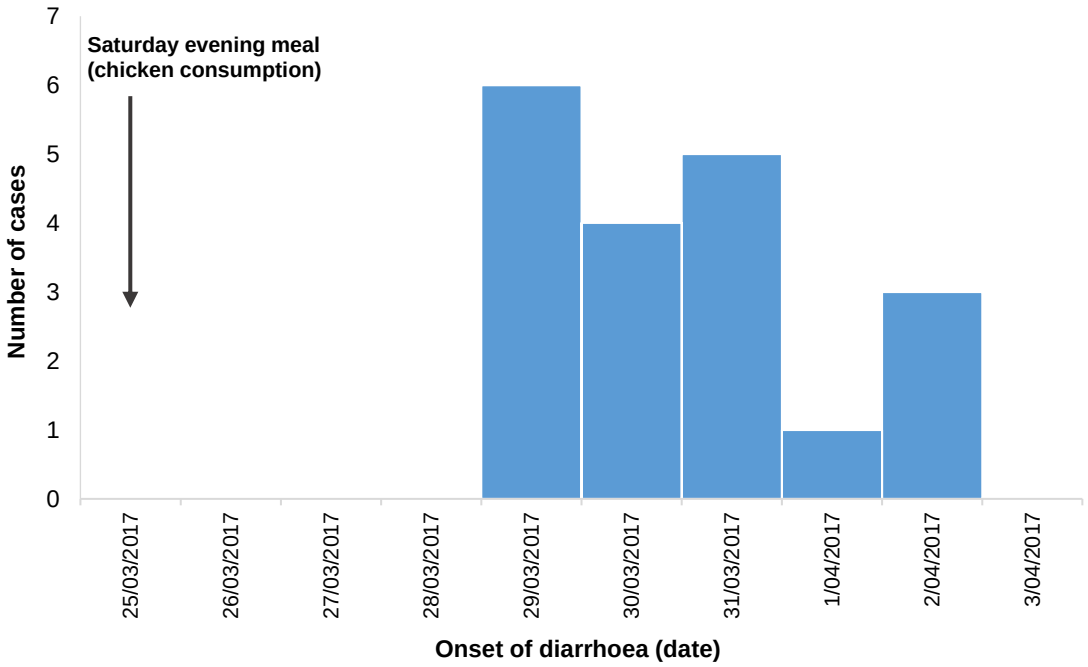
Questionnaires were completed by 75% of community members (76/101). Data from pilot interviews were included as the same questions were asked in the self-administered questionnaire. Twenty persons (26%) met the case definition. The median age of cases was 22 years (range 10–66 years). Cases were evenly distributed by sex (45% male). There was no statistically significant difference in age or gender between cases and non-cases (**Table 2-1**).

Cases reported an onset of diarrhoea from 29 March to 2 April 2017 (**Figure 2-1**). The most commonly reported symptoms included diarrhoea (100%), abdominal pain (90%), fever (80%) and lethargy (80%). Two cases (10%) reported bloody diarrhoea (**Table 2-1**). The median duration of illness was 5 days (range 1–8 days). Two cases (10%) sought medical care with a general practitioner in the neighbouring town and 15 cases (75%) sought care with a registered nurse who was onsite at the community. Of those who reported seeking medical care, 5 (29%) received treatment in the form of hydration and 14 (82%) commenced a course of antibiotics. Two persons who did not report seeking medical care also reported taking antibiotics. No cases were admitted to hospital and no deaths were reported. Sixteen cases (80%) reported taking time off work or school due to their illness. The median time off work or school was 4 days (range 1–7 days).

Table 2-1: Demographic and clinical characteristics of cases and non-cases (n=20)

	Cases (n=20)	**Non-cases (n=56)**	***p* value**
Age (years)			
Median (range)	22 (10–66)	21 (7–72)*	0.71†
Gender			
Male	9 (45%)	32 (57%)	0.35‡
Female	11 (55%)	24 (43%)	
Symptoms			
Diarrhoea	20 (100%)		
Abdominal pain	18 (90%)		
Fever	16 (80%)		
Lethargy	16 (80%)		
Nausea	14 (70%)		
Headache	13 (65%)		
Joint or muscle pain	7 (35%)		
Vomiting	3 (15%)		
Bloody diarrhoea	2 (10%)		

**Age missing for one non-case*
†Wilcoxon rank-sum (Mann-Whitney) test
‡Chi-squared test



**Onset of diarrhoea missing for one case*

Figure 2-1: Gastrointestinal illness by date of onset of diarrhoea, Outbreak of *Campylobacter* in a community in New South Wales, March–April 2017 (n=20)

Community residents attended up to four communal lunch meals and one communal evening meal between 23 and 28 March 2017. Communal meals were limited to one set menu with a single choice for the main dish, restricting heterogeneity of food consumption. No vegetarian or special diet options were included. Some food items were repeated in subsequent meals due to the availability of fresh produce grown onsite. No foods or beverages consumed at the communal meals showed a statistically significant association with illness (**Table 2-2**).

Table 2-2. Univariable analysis of foods consumed at communal meals, Outbreak of *Campylobacter* in a community in New South Wales, March-April 2017 (n=76)

Meal	Food exposures	Exposed			Unexposed					
		Cases	Total	AR%	Cases	Total	AR%	RR	95% CI	*p* value*
Thursday lunch 23 March 2017	Hash browns	15	64	23.4	0	0	n.a.	0.48	0.06-3.55	1.00
	Pork gravy	15	63	23.8	0	1	0.0	0.97	0.08-11.10	1.00
	Lettuce	12	51	23.5	1	6	16.7	1.41	0.22-9.04	1.00
	Apples	11	49	22.5	2	9	22.2	1.01	0.27-3.81	1.00
	Water	15	62	24.2	0	1	0.0	0.98	0.09-11.28	1.00
Friday lunch 24 March 2017	Spaghetti	12	49	24.5	0	0	n.a.	0.50	0.07-3.76	1.00
	Beef mince	11	47	23.4	0	1	0.0	0.96	0.08-11.13	1.00
	Ketchup	11	45	24.4	0	3	0.0	2.00	0.14-28.04	0.64
	Silverbeet	11	46	23.9	1	2	50.0	0.48	0.11-2.10	0.44
	Apples	6	37	16.2	2	5	40.0	0.41	0.11-1.49	0.24
	Water	12	46	26.1	0	0	n.a.	0.53	0.07-4.00	1.00
Saturday dinner 25 March 2017	Chicken tenders	20	75	26.7	0	0	n.a.	0.54	0.07-3.96	1.00
	Steamed rice	18	64	28.1	2	9	22.2	1.27	0.35-4.57	1.00
	Sweet sour sauce	17	65	26.2	2	7	28.6	0.92	0.26-3.16	1.00
	Salad	17	66	25.8	2	5	40.0	0.64	0.20-2.03	0.60
	Salad dressing	15	62	24.2	2	6	33.3	0.73	0.22-2.44	0.64
	Water	18	63	28.6	0	3	0.0	2.31	0.17-31.79	0.52
	Tea	3	22	13.6	4	14	28.6	0.48	0.13-1.82	0.39
	Milk	3	21	14.3	4	15	26.7	0.54	0.14-2.05	0.42

Meal	Food exposures	Exposed			Unexposed					
		Cases	Total	AR%	Cases	Total	AR%	RR	95% CI	*p* value*
Monday lunch 27 March 2017	Baked bread	18	66	27.3	0	1	0.0	1.10	0.10-12.56	1.00
	Butter	18	58	31.0	0	7	0.0	5.02	0.33-75.41	0.12
	Sliced ham	18	66	27.3	0	0	n.a.	0.55	0.07-4.07	1.00
	Noodle soup	17	59	28.8	0	4	0.0	2.92	0.20-41.65	0.37
	Salad	17	60	28.3	1	4	25.0	1.13	0.20-6.49	1.00
	Salad dressing	15	54	27.8	1	5	20.0	1.39	0.23-8.44	1.00
	Water	18	64	28.1	0	0	n.a.	0.57	0.08-4.20	1.00
	Tea	0	6	0.0	2	14	14.3	0.43	0.02-7.79	1.00
	Milk	0	6	0.0	2	14	14.3	0.43	0.02-7.79	1.00
Tuesday lunch 28 March 2017	Boiled potatoes	16	58	27.6	0	2	0.0	1.68	0.12-21.77	0.75
	Mince gravy	15	60	25.0	1	1	100.0	0.25	0.16-0.39	0.26
	Zucchini	15	55	27.3	1	2	50.0	0.55	0.13-2.33	0.49
	Apples	12	47	25.5	2	6	33.3	0.77	0.22-2.63	0.65
	Water	16	61	26.2	0	0	n.a.	0.53	0.07-3.95	1.00

Dose-response relationships were examined for chicken consumption on the Saturday evening meal, 25 March 2017. We did not identify a statistically significant linear trend between the amount of chicken pieces consumed (X^2 = 1.57, p = 0.21) or the degree of cooking (appearance) (X^2 = 0.73, p = 0.39) and illness. In addition, we did not identify a statistically significant association between increasing exposure levels and illness in relation to the amount of chicken pieces consumed, the size of chicken pieces consumed or the degree of cooking (appearance) (**Table 2-3**). However, interestingly cases did not report eating small chicken pieces or dry (well cooked) chicken pieces (**Table 2-3**).

Table 2-3. Dose-response relationships and chicken consumption, Outbreak of *Campylobacter* in a community in New South Wales, March-April 2017 (n=76)

		Cases	Total	AR%	RR*	95% CI	*p* value
No. of chicken pieces	1-3 pieces	5	14	35.7	reference	reference	reference
	4-6 pieces	9	29	31.0	0.9	0.36–2.11	1.00
	>6 pieces	6	31	19.4	0.5	0.20–1.48	0.42
Size of chicken pieces	Small	0	9	0.0	reference	reference	reference
	Medium/Large	9	28	32.1	6.6	0.42–102.60	0.06
	Mixed sizes	10	32	31.3	6.4	0.41–99.27	0.07
Degree of cooking	Dry	0	3	0.0	reference	reference	reference
	Moist	10	38	26.3	2.2	0.15–30.29	0.58
	Juicy	7	23	30.4	2.5	0.17–35.73	0.47

AR - attack rate; RR - relative risk; CI - confidence interval.
**For calculations with a zero value, 0.5 was added to all cells*

The proportion of community residents who had contact with animals was low. We did not find a statistically significant association between animal contact and illness.

2.5.2 Environmental investigation

Public health staff examined the cooking processes for each meal with kitchen staff. The process for the cooking of the chicken tenders raised concerns about possible undercooking. Frozen chicken breasts were purchased commercially and allowed to thaw in the cool room overnight on Thursday 23 March 2017. On Friday 24 March 2017, the thawed chicken breasts were cut into approximately 1-inch strips and placed in a soya sauce marinade in the cool room overnight. In the morning on Saturday 25 March 2017, the chicken tenders were breaded and partially deep fried in 1cm of oil; to the point that the exterior was crispy. The chicken tenders were then placed on 20 stainless steel trays and loaded onto a commercial oven rack. The oven rack was covered with a cloth and placed in the cool room. Prior to the evening meal, the chicken tenders were removed from the cool room and heated in a commercial oven for approximately 25 minutes at 160ºC. The chicken tenders were heated in one large batch, with all 20 trays

tightly packed on the oven rack. Temperature probes were inserted into one chicken tender on each tray to check that appropriate cooking temperatures had been reached (75º Celsius).

Communal meals have a table service structure in the community. Six community members were delegated to distribute the food to all tables in the dining hall on the evening of Saturday 25 March 2017. The trays of chicken tenders were placed on each table and persons at the table served themselves from a communal tray. There was no systematic serving process or grouping of tables by those serving the food. Mapping of cases by their table position on the Saturday evening meal showed that illness was widespread, rather than clustered on certain table groups (**Figure 2-2**). There were no reported sick food handlers among the kitchen or serving staff.

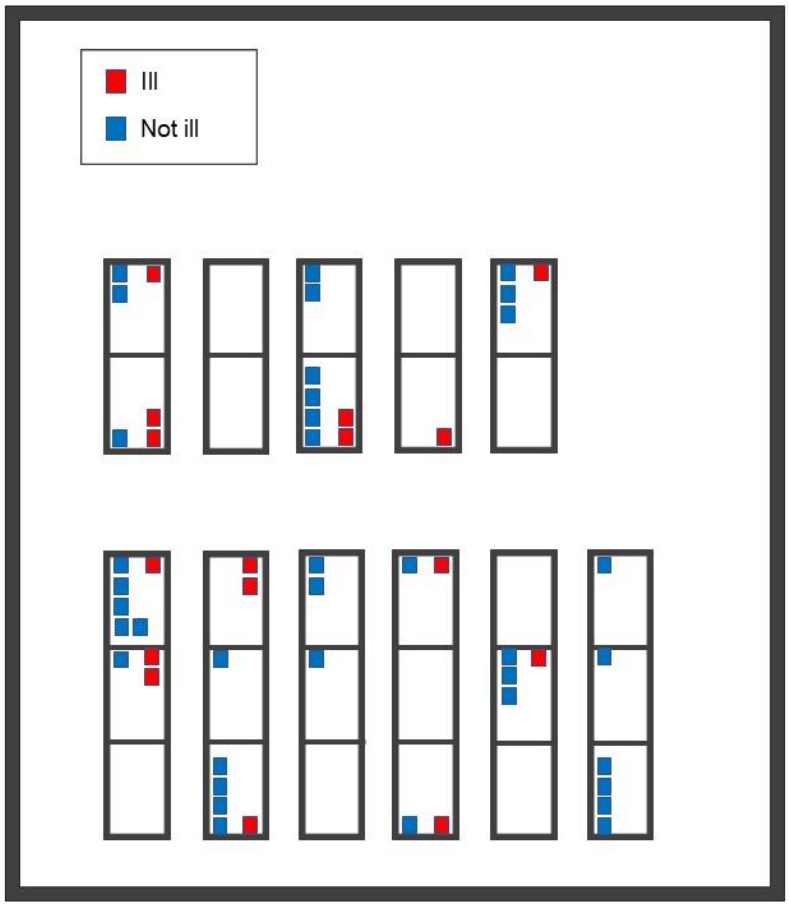


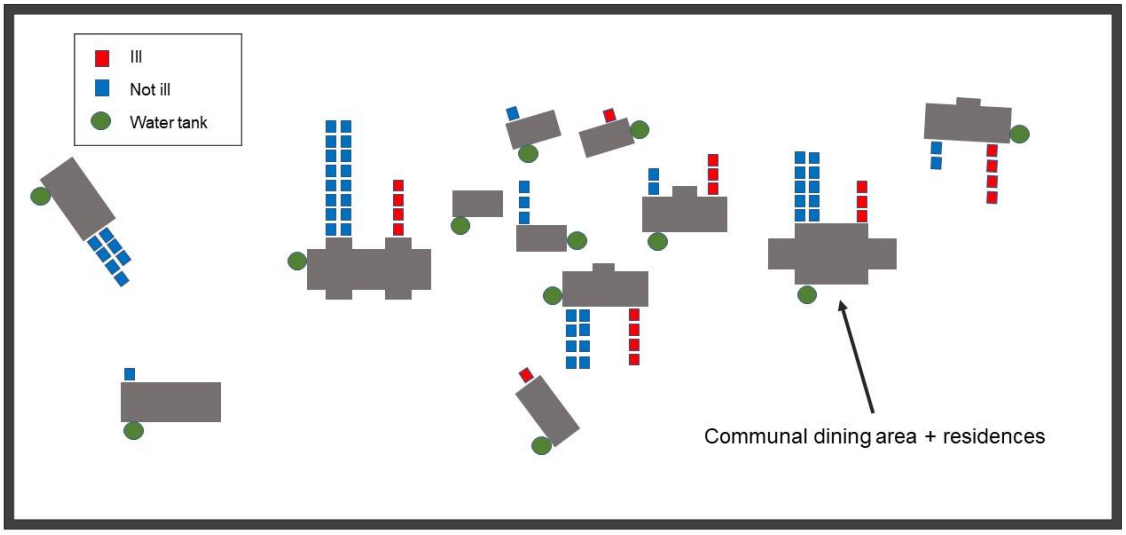
**Table location missing for 23 persons*

Figure 2-2. Reported illness by table location for Saturday evening communal meal, Outbreak of *Campylobacter* in a community in New South Wales, March-April 2017 (n=76)

Nursery-aged children (<6 years) do not attend communal meals in the community. The children did eat the same menu that was served at the Saturday evening (25 March

2017) communal meal, however the children ate earlier in the day with food that underwent a different cooking process. After the chicken tenders were deep fried, smaller pieces were picked out and placed on stainless steel trays. The trays of chicken tenders were then immediately transported to the nursery where they were placed in an oven for approximately 45 minutes before consumption. Nineteen children consumed the chicken tenders that were served in the nursery. No illness was reported in this group.

An examination of drinking water sources and water distribution in the community indicated that water was unlikely to be the source of illness. Separate rainwater tanks supplied each residential dwelling in the community. The dining hall was supplied by a rainwater tank that also supplied a residential dwelling attached to the same building. There had been no water tank issues in the community in the weeks preceding the outbreak. Mapping of cases by residential location did not reveal significant clustering, suggesting that the source of illness was more likely to be a single point source (**Figure 2-3**).



**Residential location missing for 6 respondents*

Figure 2-3. Reported illness by residential location, Outbreak of *Campylobacter* in a community in New South Wales, March-April 2017 (n=76)

2.5.3 Microbiological investigation

Four of five stool specimens collected from community members were positive for *Campylobacter*. In addition to a confirmed *Campylobacter* infection, two stool specimens were also positive for Rotavirus based on an antigen test.

2.5.4 Control measures

Public health staff determined that there was no ongoing risk at the time of the investigation. The last date of illness onset identified through the retrospective cohort study was 2 April 2017. Public health staff continued to liaise with the community representative throughout the investigation and no further cases were identified. There was no left over food product from the communal meal on Saturday 25 March 2017, which was the suspected meal of exposure. In addition, the community had proactively implemented additional infection control measures to reduce the possibility of secondary transmission in households.

The community was very receptive to health and food safety information provided by public health staff. The NSW Food Authority (NSWFA) provided advice and support to the Public Health Unit throughout the investigation, however the production of food in the community was not deemed to meet the definition of 'food for sale' and was therefore exempt from regulations under the *Food Safety Act 2003 (NSW).*

2.6 Discussion

The chicken tenders consumed on the Saturday evening meal were considered the likely vehicle for infection in this *Campylobacter* outbreak. The median incubation period for cases with an exposure on the Saturday evening meal was 5 days (range 4–8 days), which is consistent with the literature for *Campylobacter*.[8] The environmental investigation identified possible undercooking of the chicken tenders as a concern. The two-step cooking process that involved partial frying followed by re-heating of cooled chicken prior to serving may not have enabled the chicken to reach appropriate temperature controls throughout. Nursery-aged children (<6 years) who ate smaller pieces of chicken that were subject to a longer and separate cooking process did not report any illness. A dose-response relationship between chicken consumption and illness was not statistically significant. However, stratification of chicken consumption by the amount, size and degree of cooking revealed that cases were more likely to eat medium/large or mixed sized chicken pieces, rather than small chicken pieces, and were more likely to recall the chicken meat being moist or juicy, rather than dry (well cooked) (**Table 2-3**). In addition, no other food items consumed were identified as high-risk vehicles for infection with *Campylobacter*.

Undercooked poultry is a known risk factor for infection with *Campylobacter*.[15] Raw poultry products in Australia are frequently contaminated with *Campylobacter*, with a study conducted in NSW isolating the bacteria in 88% of raw retail chicken products sampled.[16] *Campylobacter* infections are generally sporadic in Australia and outbreaks

implicating *Campylobacter* as the source are infrequent. However, this may be due to limited reporting and public health follow up of cases.[17] In NSW, *Campylobacter* was only made a notifiable condition in April 2017. Reported outbreaks of *Campylobacter* in Australia have implicated raw poultry cross-contamination, undercooked poultry and poultry livers as vehicles of infection.[9,17-19]

The outbreak highlights the importance of providing food safety education to private, community settings that fall outside of legislative requirements for food safety. While food businesses in NSW must adhere to regulations under the *Food Act 2003 (NSW)*, the production of food in community settings may be exempt from regulation and monitoring if it does not meet the definition of 'food for sale.'[20] Persons preparing food in private settings still have a duty of care to exercise due diligence and ensure that safe food is provided. It is important that private, community settings have access to relevant guidelines and information to assist in maintaining food safety.

The epidemiological findings of our investigation were limited by the homogeneity of exposures among community residents. We were unable to compare the consumption of a number of food items between those who were ill and those who were not ill due to universal exposure.[21] In addition, we are unable to rule out possible cross contamination of multiple food items. Environmental sampling may have provided further detail on the source of infection, however it was not deemed an appropriate action in this investigation due to the non-commercial nature of the venue, the lack of leftover product for sampling and the time delay between the suspected exposure and the investigation. Discussions with kitchen staff and an examination of cooking processes for each meal implicated the chicken tenders consumed on the Saturday evening meal as the likely vehicle of infection. This was supported by biological plausibility and the literature surrounding outbreaks of *Campylobacter* in Australia.[22]

A strength of our investigation was the timeliness of the response, which reduced possible recall bias. The site visit and the retrospective cohort study were conducted within a week of the outbreak notification and within approximately two weeks of the suspected exposure. Whilst not all community residents responded to our questionnaire (76/101, 75%), selection bias was considered limited due to the homogeneity of exposures among residents. The exclusion of nursery-aged children may have introduced selection bias in our investigation, however it was determined that accurate information on common food exposures was unable to be obtained individually for these children as meals in the nursery were not supervised by parents. The interconnected, close-knit structure of the community may have influenced participant recall and introduced information bias. The investigation utilised a mixed method approach

including face-to-face interviews and paper-based questionnaires. To reduce possible interviewer bias, public health staff used the wording on the paper-based questionnaire during face-to-face interviews. Measurement bias may have been introduced as the questionnaire did not contain a reference for chicken size or degree of cooking. In addition, questions about chicken consumption were formatted as categorical responses rather than continuous variables, which may have led to misclassification.

2.7 Conclusion

This investigation illustrates the difficulty in making causal inferences in outbreak settings with near universal exposures. Where statistical analyses are limited by universal exposures, important evidence can be obtained through descriptive epidemiology, an examination of dose-response relationships and through environmental investigations.[21,22]

Possibly undercooked chicken tenders were considered to be the likely vehicle for infection in this *Campylobacter* outbreak. The frequent contamination of raw poultry products with *Campylobacter* in Australia is a risk for potential outbreaks. Our investigation highlights the importance of ongoing education in private, community settings to enhance food safety.

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Appendix 2.1: Questionnaire - Outbreak of *Campylobacter* in a rural community in New South Wales, March–April 2017

Contact Information	
First Name:	Last Name:
Date of birth: ___ / ___ / ___	Gender: ☐ Female ☐ Male
What is your usual place of work? _____	
Dwelling name: _____	

Clinical Information

Have you (your child) been unwell since Tuesday 28 March?

☐ Yes *(please continue)* ☐ No *(please skip to Meals section)*

When were you (your child) first unwell? Date: ___ / ___ / ___ Time: ____ AM / PM

Did you (your child) experience the following symptoms?

Diarrhoea	☐ Yes	☐ No	☐ Unsure
Blood in the stool	☐ Yes	☐ No	☐ Unsure
Fever	☐ Yes	☐ No	☐ Unsure
Abdominal pain	☐ Yes	☐ No	☐ Unsure
Nausea	☐ Yes	☐ No	☐ Unsure
Vomiting	☐ Yes	☐ No	☐ Unsure
Headache	☐ Yes	☐ No	☐ Unsure
Lethargy (tiredness)	☐ Yes	☐ No	☐ Unsure
Joint or muscle pain	☐ Yes	☐ No	☐ Unsure

Did you experience any other symptoms *(please specify)*: _____

If you (your child) had diarrhoea:

When did it start? Date: ___ / ___ / ___ Time: ____ AM / PM

On the worst day of your diarrhoea, how many episodes of diarrhoea did you experience?

☐ 2 episodes or less ☐ 3 – 10 episodes ☐ More than 10 episodes

How many days/hours did your (your child's) illness last? ___ Days / Hours ☐ Still ill

Clinical Information (continued)

Did you (your child) seek medical care your illness? ☐ Yes ☐ No ☐ Don't know

If yes, where did you seek care? ☐ Nurse ☐ General Practitioner ☐ Hospital ☐ Other

Did you receive treatment for your illness? ☐ Yes ☐ No ☐ Unsure

If yes, please specify: ☐ Hydration *(eg: Gatorade)* ☐ Antibiotics ☐ Other: _____

Did you (your child) take time off work/school due to your illness?

☐ Yes ☐ No ☐ Don't know

If yes, how many days were you (your child) off work/school? _____

Please complete all following questions regardless of whether you were well / unwell

Thursday Lunch, 23 March 2017

Did you (your child) eat this meal?

☐ Yes ☐ No *(please go to the next section)* ☐ Don't know

If yes, which of the following food items did you (your child) consume?

Hash browns	☐ Yes	☐ No	☐ Unsure	Lettuce	☐ Yes	☐ No	☐ Unsure
Pork gravy	☐ Yes	☐ No	☐ Unsure	Apples	☐ Yes	☐ No	☐ Unsure

Drinks?

Water ☐ Yes ☐ No ☐ Unsure

Do you (your child) recall eating/drinking anything else at this meal? If so, please describe:

Friday Lunch, 24 March 2017

Did you (your child) eat this meal?

☐ Yes ☐ No *(please go to the next section)* ☐ Don't know

If yes, which of the following food items did you (your child) consume?

Spaghetti	☐ Yes	☐ No	☐ Unsure	Ketchup	☐ Yes	☐ No	☐ Unsure
Hamburger mince	☐ Yes	☐ No	☐ Unsure	Silverbeet	☐ Yes	☐ No	☐ Unsure
Apples	☐ Yes	☐ No	☐ Unsure				

Drinks?

Water ☐ Yes ☐ No ☐ Unsure

Do you (your child) recall eating/drinking anything else at this meal? If so, please describe:

Saturday Supper, 25 March 2017

Did you (your child) eat this meal?

☐ Yes ☐ No *(please go to the next section)* ☐ Unsure

Which table were you sitting at? _____ *(please refer to the Dining Hall map)* ☐ Unsure

Did you (your child) eat the following foods:

1. Chicken pieces

☐ Yes ☐ No ☐ Unsure

If you ate chicken, please provide more information:

How many chicken pieces did you eat? ☐1-3 pieces ☐ 4-6 pieces ☐ More than 6 pieces

What size were the pieces you ate? ☐ Small ☐ Medium ☐ Large ☐ Mixed ☐ Unsure

How was the chicken meat cooked? ☐ Dry ☐ Moist ☐ Juicy ☐ Unsure

If juicy, were the juices: ☐ Clear ☐ Pink ☐ Unsure

2. Rice	☐ Yes	☐ No	☐ Unsure
3. Salad	☐ Yes	☐ No	☐ Unsure
4. Salad (Green) dressing	☐ Yes	☐ No	☐ Unsure
5. Sweet and sour sauce	☐ Yes	☐ No	☐ Unsure

Drinks?

1. Water	☐ Yes	☐ No	☐ Unsure
2. Tea	☐ Yes	☐ No	☐ Unsure
3. Milk	☐ Yes	☐ No	☐ Unsure

Monday Lunch, 27 March 2017

Did you (your child) eat this meal?

☐ Yes ☐ No *(please go to the next section)* ☐ Don't know

If yes, which of the following food items did you (your child) consume?

Bread	☐ Yes	☐ No	☐ Unsure	Noodle soup	☐ Yes	☐ No	☐ Unsure
Butter	☐ Yes	☐ No	☐ Unsure	Salad	☐ Yes	☐ No	☐ Unsure
Sliced ham	☐ Yes	☐ No	☐ Unsure	Salad dressing (Green)	☐ Yes	☐ No	☐ Unsure

Drinks?

Water	☐ Yes	☐ No	☐ Unsure
Tea	☐ Yes	☐ No	☐ Unsure
Milk	☐ Yes	☐ No	☐ Unsure

Do you (your child) recall eating/drinking anything else at this meal? If so, please describe:

Tuesday Lunch, 28 March 2017

Did you (your child) eat this meal?

☐ Yes ☐ No *(please go to the next section)* ☐ Don't know

If yes, which of the following food items did you (your child) consume?

Boiled potatoes	☐ Yes	☐ No	☐ Unsure	Zucchini	☐ Yes	☐ No	☐ Unsure
Hamburger mince gravy	☐ Yes	☐ No	☐ Unsure	Apples	☐ Yes	☐ No	☐ Unsure

Drinks?

Water ☐ Yes ☐ No ☐ Unsure

Do you (your child) recall eating/drinking anything else at this meal? If so, please describe:

Animal Contact Information

Have you (your child) had any contact with the following animals between Thursday 23 March 2017 and Tuesday 28 March 2017?

☐ Yes ☐ No

If yes, please tick the animal/s below describe the type of contact (touching/patting, feeding etc):

☐	Cow / calf *(please circle one)*	Type of contact: _____
☐	Horse / foal *(please circle one)*	Type of contact: _____
☐	Donkey / foal *(please circle one)*	Type of contact: _____
☐	Goat /kid *(please circle one)*	Type of contact: _____
☐	Chicken / chick *(please circle one)*	Type of contact: _____
☐	Dog / puppy *(please circle one)*	Type of contact: _____
☐	Cat / kitten *(please circle one)*	Type of contact: _____
☐	Guinea pig / rabbit *(please circle one)*	Type of contact: _____
☐	Other, please specify: _____	Type of contact: _____

Is there any other information that you think will assist our investigation?

You have now reached the end of questionnaire. Thank you for your time and assistance.

If you have any questions, please contact the Hunter New England Health Public Health Unit on (02) 4924 6477 and ask for Julie Collins or Dr Kathryn Taylor.

Chapter 3 - Other Public Health Investigations

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Preface

I was fortunate to be at the coalface of public health surveillance and response in my placement at Hunter New England Population Health. I was involved in a number of public health investigations during my placement; each providing a unique and rewarding public health experience. This chapter is intended to show the breadth of experience that I gained in public health investigations during my placement and provide some of the lessons that I learnt.

This chapter contains reports on two of the public health investigations that I was involved in at Hunter New England Population Health, as well as an investigation that I was involved in whilst deployed to Fiji through the Global Outbreak Alert and Response Network (GOARN) in May 2016. The first section (3.1) describes an outbreak investigation of gastrointestinal illness in a primary school in September 2016. The second section (3.2) describes an investigation of an outbreak of *Salmonella* Typhimurium MLVA 3-11-15-10-523 associated with a restaurant in July 2016. The third section (3.3) describes an outbreak investigation of paediatric severe acute respiratory infections (SARI) requiring admission to intensive care units in Fiji, May 2016.

Master of Philosophy (Applied Epidemiology) core activity requirements

This chapter meets the following core activity requirements:

- Preparation of an advanced draft of a paper for publication in a national or international peer-reviewed journal (**Appendix 3.1**)
- Orally presented poster presentation at a national or international scientific conference (**Appendix 3.2**)
- Preparation of a summary of public health information for a lay audience (**Appendix 3.3**)

Abbreviations

ART	Acute Response Team
CD	Communicable Diseases
CWMH	Colonial War Memorial Hospital
ED	Emergency Department
EWARS	Early Warning Alert and Response System
FCCDC	Fiji Centre for Communicable Disease Control
GOARN	Global Outbreak Alert and Response Network
GP	General Practitioner
HGQ	Hypothesis generating questionnaire
HNELHD	Hunter New England Local Health District
ICU	Intensive care unit
MLVA	Multiple-Locus Variable number tandem repeat Analysis
NoV	Noroviruses
PHU	Public Health Unit
PICU	Paediatric intensive care unit
STm	*Salmonella* Typhimurium
SydPath	St Vincent's Pathology
SARI	Severe acute respiratory infections
TEPHINET	Training Programs in Epidemiology and Public Health Interventions Network
VNTR	Variable Number Tandem Repeat
WHO	World Health Organization
WPSAR	Western Pacific Surveillance and Response Journal

3.1. An outbreak of gastrointestinal illness in a primary school in the Hunter New England Local Health District

“hyperemesis hiemis (winter vomiting disease)”

- Dr John Zahorsky, 1929

3.1.1 Prologue

3.1.1.1 My role

I was given the opportunity to lead the investigating team for this outbreak, under the guidance of program managers in the Health Protection team at Hunter New England Population Health. The investigating team consisted of a communicable disease nurse, a public health registrar, and myself.

I undertook a number of tasks during this outbreak investigation, including: interviewing the parents of suspected cases and analysing the data; liaising with clinical staff at the community hospital and maintaining a daily update on any new suspected cases; contacting the school principal and organising communication to be distributed to parents about the outbreak; liaising with multiple public health laboratories and directing the appropriate testing of specimens; and providing regular updates for the Health Protection Acute Response Team (ART).

3.1.1.2 Lessons learnt

Leading an outbreak investigation with an initially unknown cause was both challenging and rewarding. It led me to question: '*Where do you start when you are unsure of the agent? What information do you collect?'* This investigation required an iterative and responsive approach. For example, once it became clear that a toxic agent was not responsible for the outbreak, we were required to modify the laboratory testing process that had been originally established.

This investigation showed me that it is often difficult to confirm the aetiological agent responsible for an outbreak. The rapid resolution of symptoms among cases prevented specimen collection in the majority of instances. In addition, whilst the predominant symptom amongst cases was vomiting, I learnt that not all laboratories will accept vomitus specimens. In NSW, testing vomitus for biological toxins would have required shipping to an interstate laboratory.

Interactions with different laboratories as a part of this investigation enabled me to understand some of the complexities of specimen testing. In particular, it is important to be aware of the sensitivity and specificity of laboratory tests when interpreting results. I also learnt that it is important to proactively track laboratory specimens if they are required to be transferred for further testing. Despite communication between the laboratories, a positive stool specimen was discarded before it could be transferred for additional typing.

3.1.1.3 Public health impact

As a part of the outbreak investigation, enhanced communication was established between the Public Health Unit (PHU) and the local community hospital, the locum general practitioner (GP), and the associated primary school. Information about the outbreak was provided to parents of children attending the primary school. In addition, preventative information was provided to the Infection Control Nurse at the hospital for distribution to any future cases.

3.1.1.4 Acknowledgements

I was fortunate to be supported by a high level of expertise within the Health Protection team at Hunter New England Population Health. I would like to thank Rachel Latta and Kat Taylor for their assistance as a part of the outbreak investigation team. I would also like to thank James Flint, Patrick Cashman, Craig Dalton and Tony Merritt for their support and guidance.

3.1.2 Abstract

Introduction

On Friday 23 September 2016, the Public Health Unit (PHU) received notification from a community hospital that an unusually high number of children had presented to the Emergency Department (ED) with vomiting and diarrhoea that day. It was suspected that all children attended the same local primary school. The objective of the investigation was to identify if an outbreak existed, and to describe and control the outbreak.

Methods

Interviews were conducted with parents of children who were suspected to have vomiting and/or diarrhoea and who were thought to attend the associated primary school. Data were collected on patients' symptoms, illness onset, foods consumed and interactions between classes at the associated primary school. Data were analysed using Microsoft Excel 10 (Microsoft Corporation, USA), and Epi Info 7 (Centers for Disease Control and Prevention, USA).

Results

The parents of nine children were able to be contacted. All children attended the associated primary school and experienced a gastrointestinal illness from 23–24 September 2016. The predominant symptom was vomiting (100%) followed by fever (56%) and diarrhoea (44%). The median age was 10.5 years (range 6–13 years). Cases were evenly distributed by sex. Cases were clustered in the class years of Kindergarten, Year 1 and Year 5/6 (combined). One of two stool specimens submitted as a part of the investigation was positive for norovirus GII.

Conclusion

The duration of illness and symptom profile of cases were suggestive of viral gastroenteritis as the cause of this outbreak. The likely aetiological agent was norovirus GII, as confirmed by one positive stool specimen submitted as a part of the investigation.

3.1.3 Introduction

Noroviruses (NoV) account for more than 90% of viral gastroenteritis outbreaks worldwide.[1] They are single-stranded ribonucleic acid (RNA) viruses that typically cause nausea, vomiting and diarrhoea.[2] Illness resulting from norovirus is usually self-limited, with gastrointestinal symptoms lasting between 24–72 hours.[2] Outbreaks of norovirus peak during the winter months and often occur in closed settings, such as aged care facilities, childcare centres and cruise ships. The short illness duration associated with norovirus can make the cause of outbreaks difficult to detect. Often symptoms have resolved before specimens are able to be collected, thereby preventing the isolation of the outbreak pathogen. In these circumstances, the term “viral gastroenteritis” is used to define the outbreak.

There are six recognised norovirus (NoV) genogroups (GI–GVI). Three of these genogroups are known to cause human infection (GI, GII and GIV), with NoV GII strains accounting for the majority of viral gastroenteritis outbreaks.[3] In September 2016, three new NoV GII strains were detected in New South Wales (NSW): GII.17 Kawasaki 308, GII.4 New Orleans 2009/Sydney 2012 and GII.P16/Sydney 2012. The highly contagious new strains were thought to be responsible for a high incidence of viral gastroenteritis outbreaks in NSW during the winter months of 2016.[4]

Late in the evening of Friday 23 September 2016, the Infection Control Nurse from a community hospital in the Hunter New England Local Health District (HNELHD) notified the Public Health Unit (PHU) of an unusual number of children presenting to the Emergency Department (ED) with vomiting and diarrhoea. It was suspected that all children attended the same local primary school. On Saturday 24 September 2016 an investigation team from Hunter New England Health Protection was assembled with the following objectives: to determine whether an outbreak existed, and to describe and control the outbreak.

3.1.4 Methods

We considered two possible causes for the outbreak. First, we briefly considered a toxic agent due to the seemingly rapid onset of vomiting and a possible single point source of exposure from the primary school canteen. However, this hypothesis was quickly discarded after initial case interviews did not identify a common food source. Possible person-to-person transmission identified through initial interviews indicated that the likely cause of the outbreak was viral gastroenteritis. This was consistent with high levels of norovirus activity in NSW at the time of the outbreak.[4]

3.1.4.1 Case definition

We initially adopted a sensitive case definition as the outbreak pathogen and the extent of illness among the school cohort was unknown. As the investigation proceeded the likely cause was deemed to be viral gastroenteritis, and later confirmed to be norovirus. The case definition was stratified into probable and confirmed cases:

A probable case was defined as a student, staff member or visitor of the primary school with acute onset of vomiting and/or diarrhoea on or after Friday 23 September 2016.

A confirmed case was defined as a student, staff member or visitor of the primary school with acute onset of vomiting and/or diarrhoea on or after Friday 23 September 2016, with laboratory isolation of norovirus from a stool specimen.

3.1.4.2 Case finding

A line list of 11 cases presenting to ED with vomiting and diarrhoea was forwarded to the PHU from the hospital infection control nurse. An additional line list of 8 cases identified as attending the associated primary school and having symptoms of vomiting and diarrhoea, but who did not present to hospital, was also forwarded to the PHU.

The CD Nurse and I interviewed the parents of 4/11 cases that presented to hospital and 5/8 suspected cases that did not present to hospital. I contacted the community hospital daily from 24–27 September 2016 to ensure any additional cases were identified and included in the investigation.

3.1.4.3 Data collection and analysis

We collected information on symptom profile, date and time of illness onset, school year/class and attendance on 23 September 2016, and food history (focusing on whether food was consumed from the school canteen). Parents were asked to collect a stool specimen if their child had ongoing symptoms.

A descriptive analysis was conducted using Microsoft Excel 10 (Microsoft Corporation, USA), and Epi Info 7 (Centers for Disease Control and Prevention, USA).

3.1.4.4 Laboratory investigation

Stool specimens submitted as a part of the investigation were tested for norovirus using antigen and polymerase chain reaction (PCR) methods.

3.1.5 Results

One confirmed case and 8 probable cases of norovirus were identified through the investigation. The median age was 10.5 years (range 6–13 years). Cases were evenly distributed by sex (**Table 3-1**).

Table 3-1: Confirmed and probable cases by sex, outbreak associated with a primary school, Hunter New England Local Health District, September 2016

	Number	Percent
Female	5	56%
Male	4	44%
Total	**9**	**100%**

The nine identified cases attended the associated primary school. The cases were clustered in the class years of Kindergarten, Year 1 and Year 5/6 (combined year). Illness onset times ranged from 12pm on 23 September 2016 to 3am on 24 September 2016 (**Figure 3-1**). All identified cases experienced vomiting (100%), followed by fever (56%) and diarrhoea (44%) (**Table 3-2**).

Five of the nine identified cases reported eating food from the school canteen at lunch on 23 September 2016. No common food items were identified through interviews. In addition, the illness onset of three cases preceded the lunchtime meal (**Figure 3-1**). Interactions between the class years were explored, however no shared activities were identified. The class years did not share a single toilet block. Communication with parents and the school principal revealed that two of the affected class years had reported an ill student in the days prior to Friday 23 September 2016.

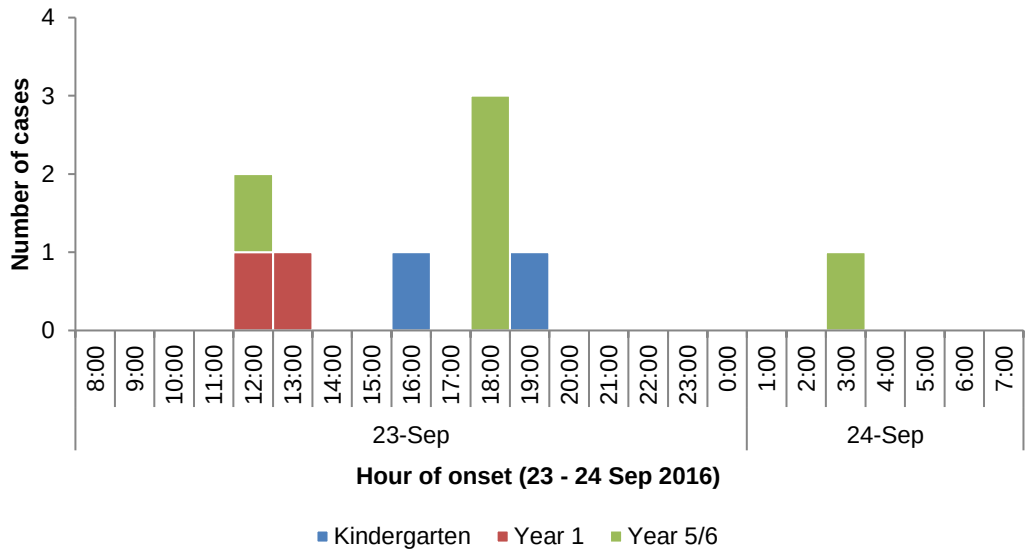

Figure 3-1: Confirmed and probable cases of norovirus by hour of illness onset (n=9)

Table 3-2: Symptom profile of confirmed and probable cases (n=9)

Symptom	Number of cases	Percent of cases
Vomiting	9	100%
Diarrhoea	4	44%
Fever	5	56%
Abdominal pain	1	11%

Two stool specimens were submitted as a part of the investigation and were sent to Pathology North NSW for norovirus testing using an antigen test. Both stool specimens tested negative for norovirus at Pathology North. The specimens were then sent to SydPath at St Vincent's Hospital in Sydney for PCR testing. One of the two stool specimens tested positive for norovirus GII. We attempted to have the stool specimen sent on to the University of New South Wales for typing in order to determine whether the outbreak was connected to one of the three new norovirus strains circulating in NSW, however the stool specimen was discarded at SydPath.

3.1.5.1 Control measures

We liaised with the principal of the associated primary school throughout the investigation. The principal organised a text message to be sent to all parents of children attending the school asking them to contact the PHU if their child experienced a gastrointestinal illness on 23 September 2016. No calls were received by the PHU.

A web link to the NSW Health Viral Gastroenteritis Fact Sheet was provided to the Infection Control Nurse at the community hospital so that staff could educate parents on control measures to prevent secondary transmission.

School holidays acted as a control measure in this outbreak as children did not attend school following Friday 23 September 2016. This decreased the institutional interaction between children and potentially decreased the spread of the outbreak.

3.1.6 Discussion

The results of the investigation indicated that the outbreak was caused by viral gastroenteritis. The likely aetiological agent in the outbreak was norovirus GII, as identified in one positive stool specimen submitted as a part of the investigation. The symptom profile among cases was consistent with norovirus infection, particularly the high proportion of cases experiencing vomiting (100%).[5]

The detection of norovirus is affected by the sensitivity and specificity of laboratory tests used. The point-of-care test based on antigen-antibody reaction used by Pathology North is 96% specific but only 84% sensitive. In comparison, the multiplex PCR test used by SydPath is DNA-based and does not require large quantities of the organism to be present for detection, resulting in higher sensitivity (personal communication, Senior Laboratory Technician, Pathology North NSW, 2016).

Norovirus strains are characterised by high levels of evolution. New, recombinant strains are more likely to cause outbreaks with high attack rates due to low levels of immunity in the population.[6,7] Three new, recombinant norovirus strains were identified to be circulating in NSW at the time of the outbreak, increasing the risk of outbreaks in the community.[4]

Whilst all cases identified in the outbreak (n=9) attended the associated primary school, a conversation with the locum general practitioner (GP) staffing the community hospital indicated that gastrointestinal illness was widespread in the community. The GP indicated that he had seen between 40–50 patients with symptoms of viral gastroenteritis between 21 and 25 September 2016. He was also aware of secondary transmission among family members of the patients that he had seen.

3.1.6.1 Limitations

The investigation began on the first day of school holidays, increasing the difficulty of communicating with parents and school staff. We were only able to interview a limited number of students (n=9) and were unable to obtain an estimate of the burden of illness in the school population due to illness onsets occurring after the school holiday closure. We also encountered difficulties in obtaining and testing specimens in order to confirm the aetiological agent in the outbreak. Due to the short duration of illness, the majority of cases were no longer experiencing symptoms at the time of interview and did not provide a stool specimen.

3.1.7 Conclusion

The symptom profile of cases, along with reports of secondary transmission within households, suggested viral gastroenteritis was the cause of this outbreak. One of two stool specimens submitted as a part of the investigation was positive for norovirus GII, indicating that this was the likely aetiological agent. We worked with the school principal to provide information to parents regarding the increase of gastroenteritis and appropriate preventative measures.

3.2. Outbreak investigation of *Salmonella* Typhimurium 3-11-15-10-523 associated with a restaurant in the Hunter New England Local Health District

3.2.1 Prologue

3.2.1.1 My role

This outbreak was detected through routine surveillance of foodborne disease notifications in the Hunter New England Local Health District (HNELHD). Collaboratively, the OzFoodNet team identified an unusual number of *Salmonella* notifications clustered in one area of the district and initiated an investigation. I co-led the investigation along with my supervisor, James Flint, and with support from OzFoodNet Research Officer, Kim Lilly.

My activities in the outbreak investigation included: interviewing cases; analysing interview data; liaising with the NSW Food Authority (NSWFA) to organise an inspection of the implicated venue; monitoring laboratory notifications to identify potential additional cases; and liaising with other health jurisdictions.

3.2.1.2 Lessons learnt

Through this investigation, I learnt the value of using laboratory data to guide an outbreak investigation. The majority of cases in this outbreak resided in a small geographic area in HNELHD, however we were able to identify an additional case from a different jurisdiction through the use of Multi-Locus Variable number tandem repeat Analysis (MLVA) data.

This investigation was a reminder of how important it is to collaborate with other jurisdictions and agencies. During the investigation we liaised with another health jurisdiction who had a case notified in their area with the same MLVA profile. We also liaised with the NSWFA who organised an inspection of the premises. The information gained through these collaborations helped us to better describe and control the outbreak.

3.2.1.3 Public health impact

As a result of the investigation, the NSWFA issued a prohibition order restricting the use of raw egg products in the implicated venue. There were no additional notifications of the same MLVA profile in HNELHD in 2016 following the prohibition order, indicating that there was no ongoing risk in the community.

3.2.1.4 Acknowledgements

I would like to thank James Flint and Kim Lilly for their support and guidance during this investigation. I would also like to thank Craig Shadbolt from NSWFA for facilitating the inspection of the implicated venue in this outbreak investigation.

3.2.2 Abstract

Introduction

On 15 August 2016, the OzFoodNet team at Hunter New England Population Health identified a cluster of four cases of *Salmonella* Typhimurium (STm) in a regional town with specimen collection dates between 26 and 31 July 2016. An outbreak investigation was initiated with the aim of describing the cases, identifying any common exposures and implementing appropriate control measures. Upon the receipt of Multiple-Locus Variable number tandem repeat Analysis (MLVA) data, an additional case was identified from another Local Health District in NSW and was included in the investigation.

Methods

We interviewed cases via telephone using the standard OzFoodNet *Salmonella* Hypothesis Generating Questionnaire (HGQ). Data were collected on clinical symptoms, travel history, environmental exposures and foods consumed in the seven days prior to onset of illness. Descriptive analyses of interview data were conducted using Microsoft Excel 10 (Microsoft Corporation, USA).

We established enhanced surveillance of laboratory notifications to identify additional cases with the same MLVA profile. In addition, we liaised with the NSWFA to conduct an environmental investigation of the implicated food premises.

Results

A total of five cases of *Salmonella* Typhimurium with the MLVA profile 3-11-15-10-523 were identified with specimen collection dates between 26 and 30 July 2016. Cases were predominately female (n=4, 80%). The median age was 24 years (range 7–63 years). Four of the five cases indicated that they had eaten at the same restaurant in the Hunter New England region during their incubation period. The fifth case was able to recall eating at a restaurant in the same vicinity but was unable to recall the restaurant name. The cases consumed a variety of raw egg products at the implicated restaurant, including chocolate mousse (n=3, 60%), hollandaise sauce (n=1, 20%) and an aioli-like sauce (n=1, 20%).

Conclusion

Raw egg products were the likely vehicle of transmission in this outbreak. The NSWFA issued a prohibition order on the use of raw egg products at the implicated restaurant on 17 August 2016. There were no further cases of *Salmonella* Typhimurium with the same MLVA profile notified in Hunter New England in 2016.

3.2.3 Introduction

Nontyphoidal *Salmonella* is a common cause of foodborne illness in Australia. It is a gram negative bacterium that typically causes a sudden onset of diarrhoea in cases, along with abdominal pain, fever, nausea and often vomiting.[2] *Salmonella* infections are usually self-limiting, but in some cases can cause serious illness and death. *Salmonella* infections can also result in long-term sequelae such as irritable bowel syndrome and reactive arthritis.[8]

There are approximately 2,500 recognised serovars (or serotypes) of *Salmonella*. In Australia, the most common serovar is *Salmonella* Typhimurium (STm).[9,10] Due to the volume of *Salmonella* Typhimurium infections in Australia, state reference laboratories have introduced additional strain typing to assist in the detection of outbreaks. The NSW Enteric Reference Laboratory at the Centre for Infectious Diseases and Microbiology (ICPMR), Westmead, have used Multi-Locus Variable number tandem repeat Analysis (MLVA) routinely since 2008.[11] The MLVA profile consists of a string of numbers representing the number of repeats of the variable number tandem repeat (VNTR) loci, or alleles.[12] The discriminatory power provided by MLVA profiles can be used by public health staff for the detection, or confirmation, of outbreaks depending on the timeframe in which results are received.

On 15 August 2016, the OzFoodNet team at Hunter New England Population Health identified four notifications of *Salmonella* Typhimurium (STm) from a regional town (Town X) in the Local Health District. The notifications were clustered in time, with specimen collection dates between 26 and 31 July 2016. We decided to initiate an investigation prior to receiving MLVA data from the NSW Enteric Reference Laboratory.

3.2.4 Methods

Interviews were conducted using the standardised OzFoodNet *Salmonella* Hypothesis Generating Questionnaire (HGQ), along with the standard priority trawler focusing on poultry and egg consumption. This questionnaire is often used at the beginning of an investigation to capture a large amount of information that might pertain to the source of the cluster.

Cases were interviewed by telephone. Data were collected on clinical symptoms, travel history, environmental exposures, and foods consumed in the seven days prior to onset of illness. Cases were also asked about eating out at any commercial food venues during their incubation period. Descriptive analyses of interview data were conducted using Microsoft Excel 10 (Microsoft Corporation, USA).

A case was initially defined as a person residing in Town X in HNELHD with a laboratory confirmed infection with *Salmonella* Typhimurium and a specimen collection date on or after 26 July 2016.

Once MLVA typing was received, the case definition was refined to be both more specific in terms of strain typing and more sensitive in terms of case distribution. Under the final case definition, a case was defined as a person residing in NSW with a laboratory confirmed infection with *Salmonella* Typhimurium MLVA profile 3-11-15-10-523 and a specimen collection date on or after 26 July 2016.

An environmental investigation of a suspected restaurant was conducted by the local council under the authority of the NSWFA. Environmental samples were collected and tested for *Salmonella*.

3.2.5 Results

A total of five cases met the final outbreak case definition. Four cases resided in HNELHD. One case resided in another Local Health District but had travelled to HNELHD during their incubation period. Specimen collection dates ranged from 26 to 31 July 2017. Cases were interviewed between 15 and 19 August 2016. The response rate was 100%.

Cases were predominately female (n=4, 80%). The median age was 24 years (range 7–63 years). All five cases reported experiencing diarrhoea, abdominal pain, nausea and lethargy (n=5, 100%). Four cases (80%) reported experiencing vomiting. The median duration of illness was 8 days (range 7–21 days). Two of the five cases were hospitalised and no deaths were reported.

Four of five cases indicated that they had eaten at a particular restaurant during their incubation period. The fifth case was able to recall eating at a restaurant in the same vicinity but was unable to recall the restaurant name. Interviews identified the consumption of raw egg products by all cases, with four cases confirming consumption of egg products at the implicated restaurant. Three cases (60%) consumed a chocolate mousse dessert. One case (20%) consumed eggs and hollandaise sauce. The remaining case (20%) recalled consuming an aioli type sauce. Mousse, hollandaise sauce and aioli are all products that may be made with raw or lightly-cooked eggs. No other common exposures were identified.

3.2.5.1 Control measures

We liaised with the NSWFA throughout our investigation. The NSWFA arranged for the local council to conduct an inspection of the implicated restaurant on 17 August 2016. The business was found to be serving a number of raw egg products. There was no chocolate mousse available as only 14 serves of the implicated batch had been prepared in late July according to the restaurant owner. A number of food items and surface swabs were collected and tested for *Salmonella*. All specimens were negative for *Salmonella* (personal communication, Craig Shadbolt, NSW Food Authority, 2016). The NSWFA issued a prohibition order preventing the further use of raw egg products at the implicated restaurant. An egg traceback investigation was not initiated given the limited number of cases and the involvement of a single venue. No additional cases linked to this MLVA profile were notified in HNELHD in 2016 following the raw egg prohibition order issued by the NSWFA.

3.2.6 Discussion

The epidemiological evidence obtained through case interviews indicated that raw egg products served at the implicated restaurant were the likely source of infection in this outbreak. The environmental investigation confirmed the sale of raw egg products at the implicated restaurant, however *Salmonella* was not identified in any environmental specimens. The chocolate mousse, which was most common food item consumed by cases, was not available for testing. *Salmonella* Typhimurium has been commonly associated with egg products in previous outbreaks in Australia.[9]

The use of enhanced strain typing for *Salmonella* Typhimurium was instrumental in enabling investigators to identify an additional case in this outbreak. *Salmonella* notifications in NSW are followed up by the LHD in which the person resides. However, due to the incidence of *Salmonella* Typhimurium in NSW, cases are only interviewed if they are suspected to be a part of an outbreak. Without the definition provided by the MLVA profile, we would not have been able to identify the additional case in this outbreak that was notified from a different LHD.

Our investigation was limited to notified cases of *Salmonella* and does not provide a true representation of the burden of illness in the community. It is estimated that for every notification of *Salmonella*, seven additional cases occur in the community.[13] We were unable to conduct active case finding or initiate a cohort study in relation to the implicated restaurant as they did not operate with a booking schedule (predominately walk-ins).

3.2.7 Conclusion

The likely vehicle of infection in this outbreak was raw egg products consumed at the implicated restaurant in HNELHD. Four of five cases recalled consuming a raw egg product at the implicated restaurant, including chocolate mousse and raw egg sauces. The implicated restaurant was issued with a prohibition order on the use of raw egg products on 17 August 2016. There were no further cases of *Salmonella* Typhimurium with the MLVA pattern 3-11-15-10-523 notified in Hunter New England in 2016.

3.3. Investigation of paediatric severe acute respiratory infections (SARI) in Fiji

3.3.1 Prologue

3.3.1.1 My role

I was deployed to Fiji for the month of May 2016 via the World Health Organization's (WHO) Global Outbreak Alert and Response Network (GOARN). I was deployed as a part of the WHO response to Tropical Cyclone Winston, a Category 5 cyclone that struck Fiji on 20–21 February 2016. My role was to provide technical support for disease surveillance, particularly the syndromic Early Warning Alert and Response System (EWARS). As a part of my role, I assisted staff at the WHO Division of Pacific Technical Support (WHO DPS) and the Fiji Centre for Communicable Disease Control (FCCDC) with cluster investigations.

Early in my deployment, I was involved in retrospective case finding for severe acute respiratory infections (SARI) among pregnant women at Colonial War Memorial Hospital (CWMH), Suva. I established a line list of suspected patients with SARI admitted between January 2014 and May 2016. Case information was extracted from patient registers at the intensive care unit (ICU) and antenatal ward at CWMH. Data analysis showed an unusually high level of SARI activity among pregnant women at CWMH in May 2016.

Hospital clinicians also had concerns about an increase in SARI in the paediatric population at the time, which led to a subsequent investigation to determine whether the children aged less than 15 years were experiencing an unusually high level of SARI in May 2016. The FCCDC and WHO established a joint investigation team and deployed members to Fiji's three divisional hospitals to conduct retrospective case finding for SARI at the paediatric intensive care units (PICU) and to establish enhanced SARI surveillance at each hospital.

I was deployed to Labasa Divisional Hospital in the Northern division as a part of the investigation, along with my FCCDC counterpart Dr Jima Kailawadoko. I conducted retrospective case finding by reviewing the patient register at the PICU at Labasa Divisional Hospital. I was also involved in training hospital staff on enhanced SARI surveillance. I analysed the investigation data from all three hospitals and developed an investigation report for the FCCDC, with support from WHO colleagues. I led the development of a paper on the outbreak investigation, which has been submitted to the Western Pacific Surveillance and Response Journal (WPSAR) (**Appendix 3.1**). I also presented this investigation as a poster at the 9th TEPHINET Global Scientific Conference in Chiang Mai, Thailand, in August 2017 (**Appendix 3.2**).

3.3.1.2 Lessons learnt

This investigation was an extremely valuable experience as it introduced me to the challenges of conducting investigations in different contexts and health systems.

The first step of an outbreak investigation, determining the existence of an outbreak, is difficult to achieve when the health department does not have ready access to historical data. As Fiji does not have an electronic health information system, we were required to manually review paper registers in order to collect baseline data. This brought a number of challenges, such as having to rely on limited and often varying quality of data in patient registers (as finding each patient's filed medical chart would not be feasible in the timeframe) and small but frustrating things like not being able to read clinicians' handwriting!

Despite the practical challenges of conducting an outbreak investigation in this context, the experience also showed me the resilience and proactive thinking of local hospitals in protecting their communities from outbreaks.

3.3.1.3 Public health impact

The outbreak investigation had immediate public health impacts around controlling the spread of SARI as it was combined with the establishment of enhanced SARI surveillance in each divisional hospital and involved raising awareness among staff, particularly those in intensive care.

3.3.1.4 Acknowledgements

I worked with a number of colleagues from the World Health Organization and the Fiji Centre for Communicable Disease Control during this investigation. From WHO, I thank: Viema Biaukula, Katri Jalava, Angela Merianos and Eric Nilles; from FCCDC, I thank: Daniel Faktaufon, Sam Fullman, Jima Kailawadoko and Mike Kama; from Hunter New England Population Health and the Australian National University, I thank: James Flint, Katrina Roper and Meru Sheel.

I would like to particularly acknowledge Jima Kailawadoko who travelled with me to the Northern Division to conduct active case finding at Labasa Divisional Hospital. I would also like to thank Katri Jalava, James Flint and Eric Nilles for their assistance and support in conducting a rapid analysis of the data for the Fiji Ministry of Health. I would like to acknowledge all authors for their contributions in the drafting of the paper for peer review.

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Appendix 3.1: Publication in the Western Pacific Surveillance and Response (WPSAR) Journal

(see following page)

An outbreak investigation of paediatric severe acute respiratory infections requiring admission to intensive care units – Fiji, May 2016

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Introduction: Influenza-associated severe acute respiratory infections (SARI) are a major contributor to global morbidity and mortality. In response to a cluster of SARI cases and deaths in pregnant women, with two deceased cases testing positive for influenza A(H1N1)pdm09, an investigation was initiated to determine whether there was an increase of paediatric SARI cases admitted to divisional hospital intensive care units in Fiji in may 2016 compared to May 2013–2015.

Methods: Retrospective case finding was conducted at the paediatric intensive care units (PICUs) in Fiji's three divisional hospitals. Data were collected from 1 January 2013 to 26 May 2016. Cases were identified using a list of clinical diagnoses compatible with SARI.

Results: A total of 632 cases of paediatric SARI with complete details were identified. The median age of cases was 6 months (Interquartile range: 2–14 months). Children aged less than 5 years had a higher rate of paediatric SARI requiring admission to a divisional hospital PICU in May 2016 compared to May 2013–2015 (Incidence rate ratio: 1.7 [95% CI: 1.1–2.6]). This increase was not observed in children aged 5–14 years. The case-fatality ratio was not significantly different in 2016 compared to previous years.

Conclusion: The investigation enabled targeted public health response measures, including enhanced SARI surveillance at divisional hospitals and an emergency influenza vaccination campaign in the Northern Division.

Influenza-associated severe acute respiratory infections (SARI) are a major contributor to global morbidity and mortality, particularly among high-risk groups such as pregnant women and children. In 2008, the World Health Organization (WHO) estimated that there were 90 million new cases of seasonal influenza globally and 20 million cases of influenza-associated acute lower respiratory infections in children less than 5 years.[1] Influenza outbreaks typically occur during winter months in countries with temperate climates. In Pacific island countries, influenza outbreaks can occur throughout the year with less seasonal variation.[2] Influenza vaccination is an effective method for the prevention of influenza infection and subsequent complications.[3] WHO recommends influenza vaccination for pregnant women and children aged 6 months to 5 years to prevent severe disease requiring hospitalization.[1]

Fiji is a tropical archipelago in the South Pacific Ocean with an estimated population of 865 611.[4] National surveillance systems in Fiji capture information on influenza-like illness; however, surveillance for SARI is limited.[5] Fiji does not currently have a seasonal influenza vaccination policy; however, vaccination is recommended for high-risk groups including health-care workers, pregnant women, elderly persons and those with chronic illnesses.[3] Influenza vaccination is not publicly funded under Fiji's national immunization programme, yet vaccines

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may be purchased privately from health-care providers.[6] Uptake of the influenza vaccine in Fiji has previously been reported as low.[7]

In May 2016, the Ministry of Health and Medical Services (MoHMS) in Fiji identified an increase in adult hospital admissions due to severe respiratory infections. In addition, a small cluster of pregnant women developed SARI, four of whom died. Two of the four deceased cases tested positive for the influenza A(H1N1)pdm09 virus.[8] In response to the increased SARI activity in adults, an investigation was conducted to determine if there was an increase in paediatric SARI cases requiring admission to divisional hospital paediatric intensive care units (PICUs) in Fiji in May 2016 compared to May 2013–2015 and to implement appropriate control measures. The investigation was led by the Fiji Centre for Communicable Disease Control (FCCDC) with support by WHO. This paper reports the findings of the investigation.

METHODS

We conducted retrospective case finding on 26–27 May 2016 at the three divisional hospital PICUs in Fiji: Colonial War Memorial Hospital (covering Central and Eastern Divisions), Labasa Divisional Hospital (Northern Division) and Lautoka Divisional Hospital (Western Division). Patient registers were reviewed to identify cases clinically compatible with SARI. Data from January 2013 to May 2016 were collected to ensure sufficient historical data to calculate baseline rates of disease.

A case-patient was defined as a child aged 0–14 years admitted to a divisional hospital PICU from 1 January 2013 to 26 May 2016 with any of the following diagnoses: pneumonia, severe pneumonia, acute respiratory distress syndrome, influenza, lower respiratory tract infection, upper respiratory tract infection or severe acute respiratory infection.

Data were collected on patients' date of admission, age, diagnosis and outcome. Population data were calculated by applying estimated growth rates to 2007 Fiji census data.[9] Incidence rates were calculated for the month of May by division and paediatric age groups available from the census data (0–4 years, 5–9 years and 10–14 years). Incidence rate ratios (IRR) and Fisher's exact 95% confidence intervals (CI) were calculated to compare incidence rates for May 2016 and May 2013–2015. The frequency and proportion of SARI cases were tabulated with a further breakdown of age for children less than 5 years (0–5 months, 6–11 months, 12–23 months, 24–35 months, 36–47 months and 48–59 months) as well as the 5–9 year and 10–14 year age categories. Case-fatality ratios (CFRs) were calculated for January–May 2016 and January–May 2013–2015. A Fisher's exact two-sided p-value was calculated to compare the 2016 and baseline case-fatality ratios. The month of May 2016 in this paper refers to data collected up to 26 May 2016 (date of the investigation); data were collected and analysed for whole months in prior years. All analyses were conducted using Stata 14.1 (StataCorp LP, College Station, USA) and Microsoft Excel 2016 (Microsoft Corporation, Redmond, USA).

RESULTS

We identified 632 cases of paediatric SARI with complete details requiring admission to divisional hospital PICUs between January 2013 and May 2016 (**Fig. 1**). The median age of paediatric SARI cases during the investigation period (January 2013–May 2016) was 6 months (Interquartile range: [IQR] 2–14 months). Ninety-three per cent (n = 586) of all cases identified during the investigation were in children aged less than 5 years. Moreover, 85% (n = 540) were in children aged less than 2 years.

Fig. 1 shows the number of cases admitted by month and year of the investigation period. The rate of paediatric SARI in children less than 5 years was higher during the month of May 2016 when compared to the same period in 2013–2015 (IRR: 1.7 [95% CI: 1.1–2.6]) (**Table 1**). The rate increase in children less than 5 years was not statistically significant when stratified by division (**Table 1**).

The CFRs were not significantly different for cases of paediatric SARI requiring admission to divisional hospital PICUs in January–May 2016 (12.5%) compared to the same period in 2013–2015 (9.1%) (P = 0.343).

Outbreak response

The FCCDC established enhanced SARI surveillance at divisional hospital PICUs to ensure continued monitoring. In addition, the FCCDC, with support from the WHO Emerging Diseases Clinical Assessment and Response Network, conducted critical care training with a particular focus on SARI for PICU staff in August 2016.

Fig. 1. **Cases of paediatric severe acute respiratory infection (SARI) admitted to divisional hospital paediatric intensive care units (PICUs) by division and month of admission, Fiji, January 2013 to May 2016 (n = 632)**

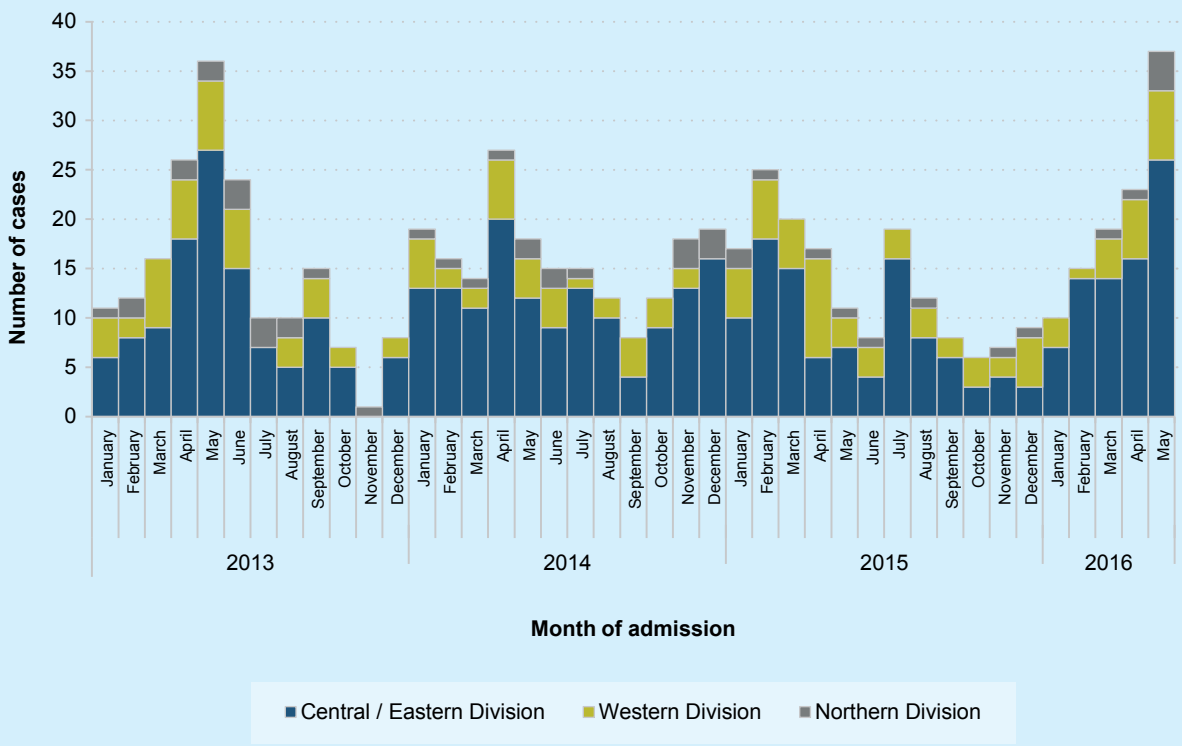

Table 1. **Incidence rate per 10 000 population and incidence rate ratio of paediatric SARI requiring admission to divisional hospital PICUs, Fiji, May 2016 and May 2013–2015**

	May 2016 IR*	May 2013–2015 IR*	IRR (95% CI)†
Central/Eastern Division			
0–4 years	5.6	3.5	1.6 (0.9–2.7)
5–9 years	0.3	0.2	1.5 (0.0–28.2)
10–14 years	0.2	-	-
Western Division			
0–4 years	2.2	1.3	1.7 (0.6–4.8)
5–9 years	-	0.2	-
10–14 years	-	-	-
Northern Division			
0–4 years	2.9	1.2	2.4 (0.5–11.2)
5–9 years	-	-	-
10–14 years	-	-	-
Divisions combined			
0–4 years	4.0	2.3	1.7 (1.1–2.6)
5–9 years	0.1	0.2	0.7 (0.0–7.5)
10–14 years	0.1	-	-
All years (0–14)	1.4	0.9	1.7 (1.1–2.6)

* Monthly incidence rates were calculated for May in each year.

† Incidence rate ratios could not be calculated for some groups because of zero counts.

CI: confidence interval, IR: incidence rate, and IRR: incidence rate ratio

Paediatric SARI activity in the Central/Eastern and Western divisions had been increasing in the months before the investigation (**Fig. 1**). However, the increase appeared to be delayed in the Northern Division, allowing an opportunity to implement preventive measures. In anticipation of an increase in paediatric SARI cases in the Northern Division, the MoHMS and WHO Division of Pacific Technical Support facilitated a donation of 6000 doses of paediatric influenza vaccine. An emergency influenza vaccination campaign in the Northern Division was jointly coordinated by the Northern Division Public Health Team, the Fiji Expanded Programme on Immunization (EPI) and Labasa Divisional Hospital from July to September 2016. The vaccination campaign targeted children aged 6–12 months and achieved 84% coverage (Fiji EPI, unpublished data, 2016).

DISCUSSION

We found that children aged less than 5 years experienced a higher rate of SARI requiring admission to divisional hospital PICUs in the month of May 2016 compared to the same month in 2013–2015. The majority of SARI cases in the investigation period occurred in children aged less than 2 years (85%), which confirms that this age group is at a high risk of severe influenza-associated respiratory infections.[1,10]

Three months before the outbreak, Fiji was struck by one of the strongest tropical cyclones recorded in the southern hemisphere. Tropical Cyclone Winston resulted in 44 deaths and caused severe damage and displacement throughout Fiji.[11] Populations in crisis have a higher risk of outbreaks of acute respiratory infections, and this may have influenced the increase in paediatric SARI requiring PICU admissions among children aged less than 5 years in May 2016.[12]

The increased incidence of paediatric SARI in May 2016 may also have been influenced by circulating influenza A viruses. Influenza A was predominant in Fiji during April–May 2016, with A(H1N1)pdm09, A(H3) and some B viruses detected.[13] The April–May period began with more notifications of A(H1N1)pdm09; however, A(H3) was predominant overall.[13] Globally, the 2015–2016 influenza season was also marked by an early predominance of the influenza A(H1N1)pdm09 virus with influenza A(H3N2) predominant later in the global season.[14,15]

Several limitations were identified in the investigation. We only measured severe disease requiring admission to paediatric intensive care units; this paper does not provide a comprehensive estimate of paediatric SARI incidence. The investigation case definition was based on clinical diagnoses, which may have resulted in some misclassification of SARI cases. The etiology of SARI was not systematically investigated as suspected cases of influenza are not routinely confirmed by microbiological testing in Fiji; the assumption that the increase in paediatric SARI was due to influenza cannot be confirmed. CFRs should be interpreted in the context of PICU admissions rather than all paediatric SARI hospitalizations. Since the investigation was conducted in May 2016, CFRs were calculated for the period January–May for each year (2013–2016) and incidence rates for the month of May only (2013–2016). Small case numbers in some divisions and age groups may have influenced the results.

While recognizing there are competing priorities for health resources, the introduction of a seasonal influenza vaccination policy for high-risk groups, as per WHO recommendations, should be considered to address the ongoing burden of paediatric SARI in Fiji.[1,3]

CONCLUSION

This investigation provided valuable information on the burden of paediatric SARI requiring admission to divisional hospital PICUs in Fiji in May 2016. The data were used to implement targeted public health response measures and enhance surveillance for paediatric SARI in divisional hospitals in Fiji.

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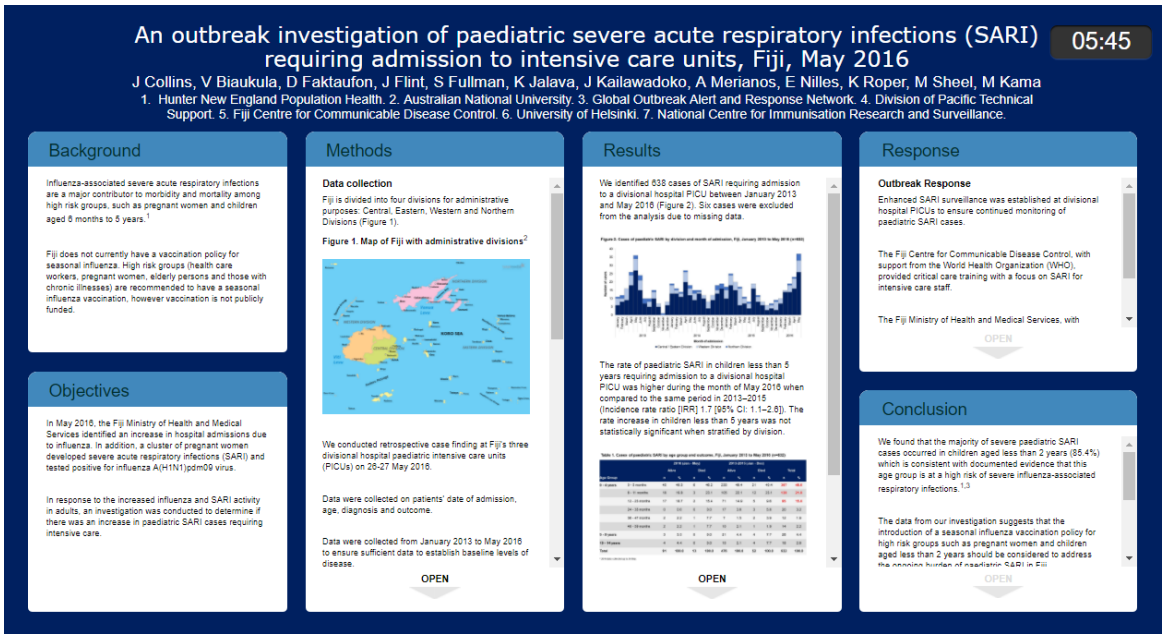
Appendix 3.2: Oral presentation of poster, 9th TEPHINET Global Scientific Conference, Chiang Mai, Thailand, 7-11 August 2017



Content

An outbreak investigation of paediatric severe acute respiratory infections (SARI) requiring admission to intensive care units, Fiji, May 2016

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Background

Influenza-associated severe acute respiratory infections are a major contributor to morbidity and mortality among high risk groups, such as pregnant women and children aged 6 months to 5 years.[1]

Fiji does not currently have a vaccination policy for seasonal influenza. High risk groups (health care workers, pregnant women, elderly persons and those with chronic illnesses) are recommended to have a seasonal influenza vaccination, however vaccination is not publicly funded.

Objectives

In May 2016, the Fiji Ministry of Health and Medical Services identified an increase in hospital admissions due to influenza. In addition, a cluster of pregnant women developed severe acute respiratory infections (SARI) and tested positive for influenza A(H1N1)pdm09 virus.

In response to the increased influenza and SARI activity in adults, an investigation was conducted to determine if there was an increase in paediatric SARI cases requiring intensive care.

Methods

Data collection

Fiji is divided into four divisions for administrative purposes: Central, Eastern, Western and Northern Divisions (Figure 1).

Figure 1. Map of Fiji with administrative divisions[2]

We conducted retrospective case finding at Fiji's three divisional hospital paediatric intensive care units (PICUs) on 26-27 May 2016.

Data were collected on patients' date of admission, age, diagnosis and outcome.

Data were collected from January 2013 to May 2016 to ensure sufficient data to establish baseline levels of disease.

Dr Daniel Faktaufon, Mr James Flint and Surveillance Officers reviewing PICU registers in Central Division

Case definition

A case was defined as a child aged 0–14 years admitted to one of the three divisional hospital PICUs between 1 January 2013 and 26 May 2016 with a clinical diagnosis compatible with SARI.*

Data analysis

Incidence rates were calculated for the month of May by division and paediatric age group. Population data were obtained by applying estimated growth rates to 2007 Fiji census data. Incidence rate ratios and 95% confidence intervals were calculated using Fisher's exact test.

The frequency and proportion of SARI cases were tabulated with a further breakdown of age for children less than 5 years.

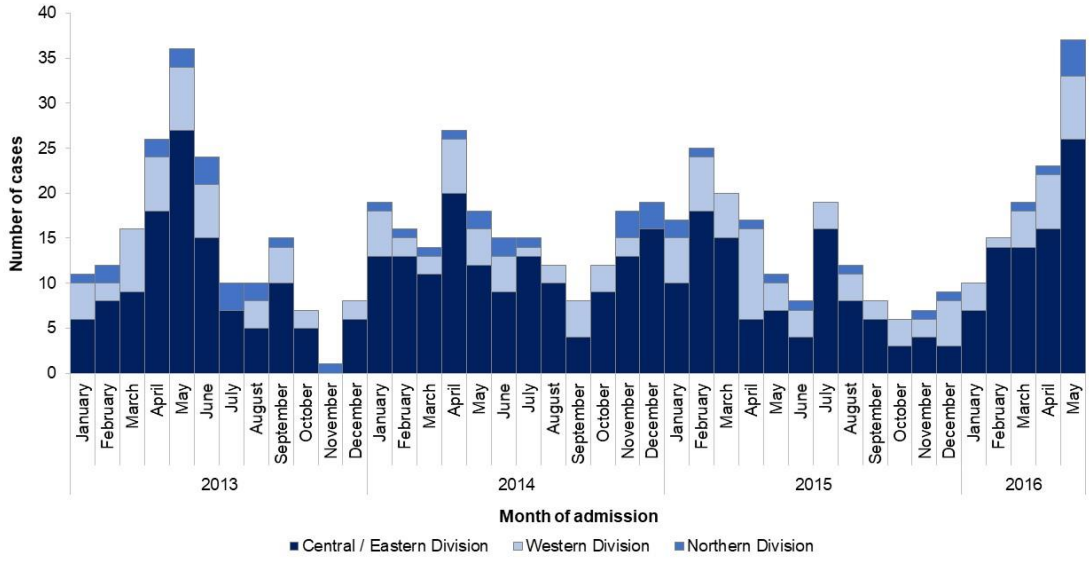
Case-fatality ratios were calculated for January–May 2016 and the same period in 2013–2015.

**Diagnoses included pneumonia, severe pneumonia, acute respiratory distress syndrome, influenza, lower respiratory tract infection, upper respiratory tract infection, or severe acute respiratory infection.*

Results

We identified 638 cases of SARI requiring admission to a divisional hospital PICU between January 2013 and May 2016 (Figure 2). Six cases were excluded from the analysis due to missing data.

Figure 2. Cases of paediatric SARI by division and month of admission, Fiji, January 2013 to May 2016 (n=632)



The rate of paediatric SARI in children less than 5 years requiring admission to a divisional hospital PICU was higher during the month of May 2016 when compared to

the same period in 2013–2015 (Incidence rate ratio [IRR] 1.7 [95% CI: 1.1–2.6]). The rate increase in children less than 5 years was not statistically significant when stratified by division.

Table 1. Cases of paediatric SARI by age group and outcome, Fiji, January 2013 to May 2016 (n=632)

		2016 (Jan - May)				2013-2015 (Jan - Dec)					
		Alive		Died		Alive		Died		Total	
Age Group		n	%	n	%	n	%	n	%	n	%
0 - 4 years	0 - 5 months	45	49.5	6	46.2	235	49.4	21	40.4	307	48.6
	6 - 11 months	18	19.8	3	23.1	105	22.1	12	23.1	138	21.8
	12 - 23 months	17	18.7	2	15.4	71	14.9	5	9.6	95	15.0
	24 - 35 months	0	0.0	0	0.0	17	3.6	3	5.8	20	3.2
	36 - 47 months	2	2.2	1	7.7	7	1.5	2	3.9	12	1.9
	48 - 59 months	2	2.2	1	7.7	10	2.1	1	1.9	14	2.2
5 - 9 years		3	3.3	0	0.0	21	4.4	4	7.7	28	4.4
10 - 14 years		4	4.4	0	0.0	10	2.1	4	7.7	18	2.9
Total		91	100.0	13	100.0	476	100.0	52	100.0	632	100.0

* 2016 data collected up to 26 May.

The majority of paediatric SARI cases requiring admission to divisional hospital PICUs in the investigation period occurred in children aged less than 2 years (85.4%) (Table 1). The median age was 6 months (IQR 2–14 months).

The case-fatality ratio (CFR) was not significantly higher during January–May 2016 (12.5%) compared to the same period in 2013–2015 (9.1%) (p = 0.212).

Response

Enhanced SARI surveillance was established at divisional hospital PICUs to ensure continued monitoring of paediatric SARI cases.

The Fiji Centre for Communicable Disease Control, with support from the World Health Organization (WHO), provided critical care training with a focus on SARI for intensive care staff.

The Fiji Ministry of Health and Medical Services, with support from WHO, facilitated a donation of paediatric seasonal influenza vaccine in order to prevent an anticipated increase in SARI cases in the Northern Division. Children aged 6-12 months in the Northern Division were vaccinated, with 84% coverage.

Conclusion

We found that the majority of severe paediatric SARI cases occurred in children aged less than 2 years (85.4%) which is consistent with documented evidence that this age group is at a high risk of severe influenza-associated respiratory infections.[1,3]

The data from our investigation suggests that the introduction of a seasonal influenza vaccination policy for high risk groups such as pregnant women and children aged less than 2 years should be considered to address the ongoing burden of paediatric SARI in Fiji.

Acknowledgements

We would like to thank the clinical staff at divisional hospitals for their assistance with the outbreak investigation. Also the staff at the Ministry of Health and Medical Services, the Fiji Pharmaceutical and Biomedical Services Centre, the World Health Organization, Northern Division Public Health and Labasa Hospital Paediatric Unit for their support in the implementation of the emergency seasonal influenza vaccination campaign.

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Appendix 3.3: Summary of public health information for a lay audience - Infection control factsheet for food premises affected by a norovirus outbreak

FACTSHEET

Health
Hunter New England
Local Health District

INFECTION CONTROL FOR NOROVIRUS OUTBREAKS

WHAT IS NOROVIRUS?

Gastroenteritis caused by norovirus usually starts suddenly and causes vomiting and diarrhoea. People may also have nausea, fever, abdominal pain and headaches. People generally start having symptoms between 24–48 hours after ingesting the virus, but symptoms can appear as early as 12 hours after someone is exposed. The illness generally lasts for one or two days.

HOW IS NOROVIRUS SPREAD?

Norovirus is highly infectious and can be spread through a number of ways:

- **Contact with the vomit or faeces of an infected person**
  When people vomit, the particles can become airborne. This means people in the same environment as the vomit can also be infected, even if they don't have direct contact.
- **Person-to-person contact with someone who has the virus**
  Eg. Shaking hands with someone who has been sick and has the virus on their hands
- **Contaminated objects or surfaces**
  Norovirus can survive for extended periods of time on clothing and linens, as well as hard surfaces. The virus can survive high levels of chlorine, freezing and heating – making it difficult to eliminate.
- **Contaminated food or drinks**
  Food and drink can easily become infected with norovirus. Foods that are not cooked but require preparation are at a high risk of being contaminated (Eg. Salads, sandwiches or bakery products). Some foods, such as shellfish, may become infected with norovirus prior to the preparation step.

MEASURES TO ASSIST IN PREVENTING OUTBREAKS OF NOROVIRUS

Protecting staff and customers

Ill staff should be sent home immediately and excluded from work until 48 hours after their symptoms have stopped. People can still spread the virus for days after their symptoms have stopped, although the risk is lower. A clearance stool specimen is not required prior to returning to work, however the 48 hour exclusion period should be followed.

Approximately 30% of people who have a norovirus infection will not show any symptoms. These people can still spread the virus, so it is important to maintain strict hand hygiene procedures (regular washing of hands with water and soap and the use of gloves where appropriate).

Enhanced environmental cleaning

Enhanced environmental cleaning can assist in preventing the spread of norovirus. Frequently touched surfaces such as door handles, lift buttons and tables should be cleaned more frequently than normal. Washrooms should be cleaned more frequently, with particular attention paid to toilet seats, flush handles, basin taps and toilet door handles. These surfaces should be cleaned twice a day, as well as after periods of high use. Surfaces should be cleaned using detergent and warm water. Disinfection using bleach should be used for surfaces that are visibly soiled (see Cleaning and Disinfecting Soiled Areas).

CLEANING AND DISINFECTING SOILED AREAS

To prevent the spread of norovirus from soiled areas (vomiting or diarrhoeal episode), a two-step process needs to be employed.

1. Cleaning the area

Surfaces need to be cleaned free of vomit or faeces using a neutral detergent and warm water.

- Isolate the area (Vomit particles can be aerosolised. If a person vomits in a public area, all people in that area should be removed and the area cleaned).
- Wear disposable gloves, a mask and eye protection to prevent direct contact or contact with aerosolised particles.
- Absorb and remove as much of the vomit/faeces as possible using disposable towels/cloths. Discard the disposable towel/cloth in a leak-proof plastic bag.
- Clean soiled areas with detergent and warm water using a disposable cloth. Discard cloth immediately in a leak-proof plastic bag.

- Discard used gloves in leak-proof plastic bag and apply clean gloves before continuing with the disinfection step.

2a. Disinfecting the area (hard surfaces)

A bleach solution is required to disinfect surfaces.

- Use freshly-made bleach solution (dilution instructions on page 3).
- Wipe the area with a bleach solution using disposable towels/cloth.
- Leave bleach solution on the surface for at least 10 minutes (time needed to kill the virus).
- Dispose of towels/cloths, gloves and mask in a leak-proof plastic bag.
- Clean eye protection using warm water and detergent.
- Wash hands thoroughly using soap and water.

Notes for using bleach:

- Gloves should be worn when handling and preparing bleach solutions.
- Bleach solution should be made up daily.
- Bleach should be used mainly on hard, non-porous surfaces.
- Bleach can damage textiles and are corrosive to metals.

2b. Disinfecting the area (carpet)

- Bleach is not usually recommended for carpets as prolonged contact is necessary and carpets are not usually bleach resistant.
- Vacuuming is not recommended as this has the potential to recirculate norovirus particles.
- Steam cleaning should be employed to disinfect contaminated carpets (heat >60 degrees).
- The cleaner should use appropriate personal protective equipment (gown, mask, gloves and eye protection) to prevent infection.

Note: Carpets are difficult to disinfect. Outbreaks of norovirus have reoccurred even after carpets have been steam cleaned.

Preparation of bleach solution

Household bleach may come in different strengths of the active ingredient - hypochlorous acid. You can find information on the strength of the product on the product label. Below is a table to assist you in preparing the appropriate dilution of bleach solution to disinfect areas for norovirus.

Recipes to achieve a 1000 ppm (0.1%) bleach solution[1]

Original strength of bleach		Disinfectant recipe		Volume of bleach in a standard 10L bucket
Percent (%)	**Parts per million (ppm)**	**Parts of bleach**	**Parts of water**	
1	10,000	1	9	1000 ml (1L)
2	20,000	1	19	500 ml
3	30,000	1	29	333 ml
4	40,000	1	39	250 ml
5	50,000	1	49	200 ml

SPLASH INCIDENTS

If someone has had direct contact with vomit/faeces, the following cleaning measures should be employed:

- If on the skin, wash with water and soap.
- If the eyes have been splashed with vomit/faeces, wash with water.
- If the mouth has been splashed with vomit/faeces, spit out any contaminated fluids. Rinse the mouth several times with water.

LAUNDRY

- Gloves should be worn when handling soiled linen. Additional protective equipment (gown, mask, eye protection) may be necessary if there is a risk of splashing or spraying vomit/faeces.
- Soiled linen should have minimal handling to prevent generating aerosols.
- Contaminated linen should be washed using detergent and hot water for the maximum washing cycle.
- Used non-disposable mop heads should be laundered in a hot wash.

MORE INFORMATION

Information for this fact sheet has been primarily sourced from the *Guidelines for the public health management of gastroenteritis outbreaks due to norovirus or suspected viral agents in Australia* (Reference 1).

[1]*Guidelines for the public health management of gastroenteritis outbreaks due to norovirus or suspected viral agents in Australia.* p.48.

References

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Chapter 4 - Epidemiological project and data analysis

Identifying the sources of *Salmonella* enterica serovar Wangata infections in north east New South Wales: A combined epidemiological and molecular approach

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Abbreviations

ABS	Australian Bureau of Statistics
CIDM-PH	Centre for Infectious Diseases and Microbiology – Public Health
EHO	Environmental Health Officer
G-NAF	PSMA Geocoded National Address File
ICPMR	Institute of Clinical Pathology and Medical Research
km	Kilometres
LGA	Local Government Area
LHD	Local Health District
NCIMS	NSW Notifiable Conditions Information Management System
NSW	New South Wales
PHU	Public Health Unit
ROC	Receiver Operating Characteristic
S. Wangata	*Salmonella* Wangata
*S*Tm	*Salmonella* Typhimurium
WGS	Whole genome sequencing

4.1 Prologue

4.1.1 My role

The OzFoodNet sentinel site at Hunter New England Population Health has been monitoring the rising number of notifications of *Salmonella* serovar Wangata (*S*. Wangata) infections in New South Wales (NSW) over the last 5 years. At the start of my placement James Flint, my supervisor and Coordinating Epidemiologist for the OzFoodNet sentinel site, put forward the idea of conducting an epidemiological study to investigate the sources of *S.* Wangata infection, which were suspected to be environmental rather than foodborne.

With the support of David Durrheim, Director of Health Protection, we gathered support in the following months from neighbouring Local Health Districts (LHDs), the NSW Ministry of Health, veterinary colleagues from the University of Sydney, and laboratory colleagues from the Institute of Clinical Pathology and Medical Research to build a collaborative, One Health project group **(Appendix 4.1**).

I was fortunate to be involved in this project from its initial design to implementation. I co-led the project with Investigator Kelly Simpson from the University of Sydney. I led the human health component of the project (case-control study). Kelly Simpson led the animal/environmental component of the project (environmental sampling) and was highly involved in the laboratory component (culturing of environmental sampling and bioinformatics analysis for whole genome sequencing).

With support from the Project Advisory Group, I developed the research protocol and obtained human ethics approval from two ethics committees and site approval from four LHDs in NSW. Under the guidance of the Project Advisory Group, I drafted a grant proposal that was submitted to the NSW Public Health Pathogen Genomics Partnership for funding to undertake whole genome sequencing as a part of the project. We were successful in obtaining this genomics grant.

I developed the questionnaire for the case-control study, with valuable input from the OzFoodNet team and Kelly Simpson and Siobhan Mor. I was involved in all aspects of the case-control study administration, from identifying cases and controls, to interviewing, to analysis. I conducted separate multivariable logistic regression models for each control group. I presented the results of the first control group (*Salmonella* Typhimurium controls) at the Communicable Disease Control Conference in Melbourne, June 2017.

I coordinated the piloting of the environmental sampling protocol with Environmental Health teams from each LHD and assisted Kelly Simpson in conducting the pilots. During the data collection period, I coordinated the sampling visits with cases and Environmental Health teams. I was also fortunate to be involved in one of the environmental sample collections in the Hunter New England region.

I provided overall management for the project and liaised regularly with project members. I circulated reports throughout the duration of the project to keep members informed of the project's progress.

Due to delays in accessing the computers necessary for bioinformatics analysis, the whole genome sequencing analysis was not finalised at the conclusion of the Master of Philosophy in Applied Epidemiology (MAE) program. In this thesis, I have included the preliminary results of the case-control study and the environmental sampling components of this project. A final analysis of case-control study data will be conducted following the completion of whole genome sequencing and will take into account any additional epidemiological information gained through the bioinformatics analysis. Hence, numbers reported in this chapter may not align with eventual publications for this project.

4.1.2 Lessons learnt

This project helped me to understand many different aspects and complexities of an epidemiological project. One of the greatest lessons that I learnt during this project was the value that can be achieved from engaging stakeholders early and seeking active contributions throughout the project. Meeting stakeholders face-to-face, where possible, and then regularly touching base by telephone or email helps to build rapport and maintain ongoing engagement with the project. My placement supported me to meet with veterinary colleagues in Sydney and to travel to the Mid North Coast and Northern NSW Public Health Units (PHUs) to meet with Environmental Health teams; these meetings were very valuable and built a strong foundation for ongoing communication.

I learnt about study design in relation to case-control studies and the benefits and limitations of different control groups. I learnt important lessons in relation to designing appropriate questionnaires and how wording differences can impact your responses. I also found that errors can still be made in your questionnaire no matter how many times you check the document! I learnt the intricacies of applying the same questionnaire to different administration methods, including telephone interviews, online and paper-based methods. In addition, I learnt valuable statistical analysis skills in multivariable logistic regression through this project.

The dual nature of this project as a public health response and an investigative research activity taught me to balance both resources and expectations. The project helped me to understand realistic timeframes for different project components such as ethics approvals, data collection and data analysis.

4.1.3 Public health impact

This is the first known investigation of environmental risk factors for human infection with *S.* Wangata in Australia. The project findings are an important contribution to the understanding of environmental sources and transmission pathways for *Salmonella* in Australia and will assist public health professionals in future surveillance and outbreak response activities for *S.* Wangata.

This is the first occasion that *S.* Wangata isolates have been whole genome sequenced in Australia. In fact, sequence data is very limited worldwide for this serovar (personal communication, Grant Hill-Cawthorne, University of Sydney, 2017). As a part of the whole genome sequencing component of this project, a reference genome will be created for *S.* Wangata which will assist future molecular research.

4.1.4 Acknowledgements

This project was supported by enthusiastic and highly skilled public health professionals and researchers. I would foremost like to thank my supervisor, James Flint, for his support and patience during every step of this project. I would like to thank my colleague, Kim Lilly, for her wonderful technical skills, attention to detail and for always being my sounding board for any frustrations or challenges.

I would like to thank Kelly Simpson for co-leading this project with me and for the significant time and investments she made in the project. It was fantastic having a veterinary perspective in each aspect of the project. I would also like to thank Kelly's supervisors and the other members of our Project Advisory Group who provided valuable expertise and guidance.

I would like to thank Health Protection and Public Health Directors, David Durrheim and Greg Bell, for allowing us to conduct this investigation in their respective jurisdictions and for providing the support and resources to ensure a successful project. I would also like to thank the Environmental Health teams from each PHU for their commitment and zeal for the environmental sampling component of the project. It was always exciting to receive feedback from the teams after a sample run.

I would like to thank the NSW Enteric Reference Laboratory and the Centre for Infectious Diseases and Microbiology – Public Health at the Institute of Clinical Pathology and

Medical Research for their contributions to the serotyping and whole genome sequencing of isolates. I would also like to thank John Bates from Forensic and Scientific Services, for providing isolates from NSW residents that were tested in Queensland laboratories for inclusion in the project. I would particularly like to thank the NSW Public Health Pathogen Genomics Partnership for funding the whole genome sequencing of isolates under this project.

I would like to thank my academic supervisors Buddhima Lokuge, Stephanie Davis and Katrina Roper from the Australian National University for their guidance in the design, implementation and analysis of this project. I would also particularly like to thank Michelle Butler from Hunter New England Population Health and Hwan-Jin Yoon from the Statistical Consulting Unit at the Australian National University for their statistical advice in the analysis of the case-control study data.

4.1.5 Master of Philosophy (Applied Epidemiology) core activity requirements

This chapter meets the following core activity requirements:

- Analysis of a public health dataset;
- Design and conduct an epidemiological study;
- Literature review that demonstrates skills in conducting a targeted literature search and synthesis (**Appendix 4.2**);
- Oral presentation of a project at a national or international scientific conference (**Appendix 4.3**).

4.2 Abstract

Introduction

Salmonella Wangata (*S*. Wangata) is the second highest notified serovar in north east New South Wales (NSW). In comparison, notifications for this serovar are low in other parts of the state. Case interviews over the last five years (2011–2015) have suggested an environmental reservoir for this serovar. Using a One Health approach, we conducted an investigation to identify environmental risk factors for human infection and possible environmental sources for *S.* Wangata in the north east NSW region.

Methods

The project was comprised of three components: a case-control study examining environmental risk factors for human infections; targeted environmental sampling at cases' residences; and whole genome sequencing of human and environmental isolates. We conducted the case-control study from November 2016–April 2017 in three Local Health Districts in north east New South Wales. We identified cases from laboratory confirmed *S.* Wangata notifications. We used two different control groups: cases of *Salmonella* Typhimurium (STm) and neighbourhood controls. We collected information on property exposures, outdoor activities and indirect and direct contact with household pets, livestock and wildlife animals. Descriptive analyses and unconditional multivariable logistic regression models were conducted separately for each control group to identify statistically significant risk factors. We collected water, soil and animal faecal samples from cases' residences to identify if *S.* Wangata was present in their environments. Wildlife carers in the study region also provided animal faecal samples for inclusion in the project. Animal and environmental samples were cultured for *Salmonella* species, then serotyped. Human and environmental *S.* Wangata isolates were whole genome sequenced to determine their relatedness.

Results

We received 76 notifications of *S.* Wangata during the study period. We enrolled 52 eligible cases, 55 STm controls and 137 neighbourhood controls. Cases were evenly distributed by sex (54% male) and were predominately located in the Northern NSW Local Health District. A high proportion (35%) of cases were aged 65 years and over. After adjusting for other variables, we found a statistically significant association between *S.* Wangata infection and indirect contact with bats or flying foxes, native birds and native frogs in the final models. We did not find an association between animal contact with household pets or livestock animals and infection. In addition, we did not find any

association between property exposures or outdoor activities and infection. We collected 207 environmental samples from cases' residences and received 48 animal faecal specimens from wildlife carers. *Salmonella* (species level) was detected in 17 environmental samples, with 9 matching the serovar Wangata. Positive *S.* Wangata samples were detected in 3 wildlife faecal specimens, 1 compost and 1 pet dog specimen from cases' residences. *S.* Wangata was also detected in 2 green sea turtles, 1 black swan and 1 pelican sampled by wildlife carers.

Conclusion

Our results indicate that *S.* Wangata may have a reservoir in native wildlife populations in Australia. Indirect transmission pathways for human infection are supported by the ability of *S.* Wangata to infect multiple hosts and to survive well in the environment. Whole genome sequencing may provide greater clarity on the relatedness between human and environmental isolates in this project. Further research into the prevalence of *S.* Wangata among wildlife populations would enhance our understanding of environmental transmission pathways and support the implementation of appropriate control measures.

4.3 Introduction

Nontyphoidal salmonellosis causes an enteric illness that is usually self-limiting but can result in long term sequelae, such as irritable bowel syndrome and reactive arthritis.[1] There are approximately 2,500 different serovars (or strains) of *Salmonella*, each with differences in geographical distributions and epidemiological features. The majority of human infections with *Salmonella* in Australia have been attributed to foodborne transmission pathways.[2] This is largely driven by the predominance of *Salmonella* serovar Typhimurium (STm), which has commonly been associated with eggs in outbreak investigations.[3] Environmental, waterborne and zoonotic transmission pathways are less well understood by researchers, however they are of critical importance in helping health authorities improve control measures and reduce infections within Australian communities.[2,3]

Most *Salmonella* serovars can be carried and transmitted by a range of zoonotic hosts.[4,5] In addition, the bacteria can survive well in the environment.[6,7] Studies of wildlife reservoirs in Australia have often been ad hoc and focused on specific sub groups in animal populations. *Salmonella* has been detected in a range of Australian wildlife, including reptiles, amphibians, wild and aquatic birds, kangaroos and other macropods, quolls, and native rodents.[6-15] In addition, *Salmonella* outbreaks have been associated with recreational water and household environments in Australia.[16,17] The distribution of *Salmonella* serovars is dependent on both host and environmental factors.[6] Due to the diverse climatic and ecological variations in Australia, certain serovars appear to have established ecological niches in parts of the country.[3,6]

In north east New South Wales (NSW), *Salmonella* serovar Wangata (*S*. Wangata) was the second highest notified serovar (following Typhimurium) from 2011 to July 2016 (unpublished data, NSW Notifiable Conditions Information Management System, 2016). In comparison, notifications of this serovar were very low in other parts of the state. Notified cases of *S.* Wangata are routinely followed up by public health staff in NSW. However, case interviews over the last five years (2011–2015) did not identify any common food exposures (unpublished data, OzFoodNet, Hunter New England Population Health, 2016). The geographical distribution of *S.* Wangata and data from case interviews suggested an environmental reservoir for this serovar.

This epidemiological study is the first known research into environmental, waterborne and zoonotic (hereafter 'environmental') transmission pathways for human infection with *S.* Wangata in Australia to date. Using a One Health approach, we incorporated human health, animal health and laboratory elements in the design of our project (**Figure 4-1**). The Project Advisory Group included public health staff from neighbouring health

jurisdictions, veterinary and public health experts from the University of Sydney, and laboratory experts from the Centre for Infectious Diseases and Microbiology – Public Health (CIDM-PH) at the Institute for Clinical Pathology and Medical Research (ICPMR) in Westmead (**Appendix 4.1**). We obtained funding from the NSW Public Health Pathogen Genomics Partnership to conduct whole genome sequencing as a part of the project.

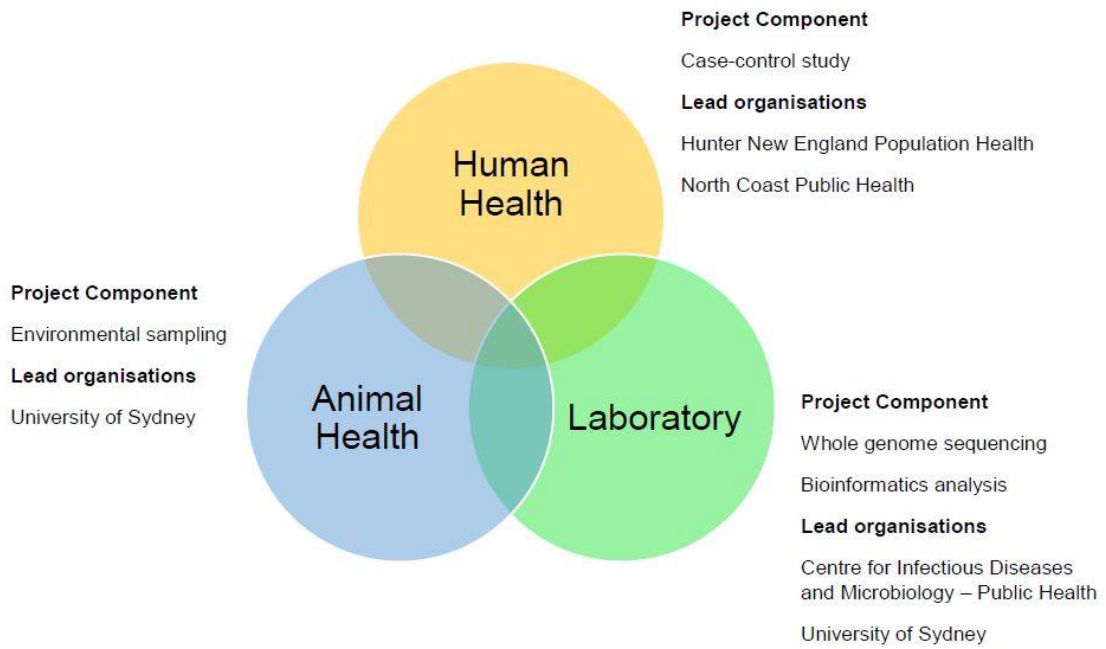

Figure 4-1: *Salmonella* Wangata One Health project design

4.4 Aims and Objectives

We aimed to investigate the epidemiological and genomic characteristics of *S.* Wangata infections in the Hunter New England, Mid North Coast and Northern NSW Local Health Districts.

Our objectives were to:

- Describe the clinical symptoms of infection using data collected through case interviews;
- Identify any significant risk factors in the demographic and behavioural profile of cases by comparing them to a control group;
- Collect animal and environmental specimens from cases' residences to determine if *Salmonella* can be detected in their environments;

- Characterise isolates from humans, animals and the environment through the use of whole genome sequencing and bioinformatics analysis.

As bioinformatics analysis for this project is currently underway, I will be reporting on the first three objectives in this chapter. The fourth objective is being addressed through ongoing work and will be reported on via a publication after the completion of bioinformatics analysis.

4.5 Methods

The project was comprised of three components:

- A case-control study examining environmental risk factors for human infections
- Targeted environmental sampling at cases' residences
- Whole genome sequencing of human and environmental isolates

The methods for each component are outlined separately below.

4.5.1 Case-Control Study

We conducted a case-control study with two control groups running in parallel. The first control group utilised a case-case methodology and consisted of persons with a notified *Salmonella* Typhimurium (STm) infection.[18,19] *Salmonella* Typhimurium is the most commonly notified serovar in Australia and is generally associated with contaminated food sources, particularly eggs.[3,20] *Salmonella* Typhimurium controls (STm controls) were frequency matched to cases by age group. The second control group consisted of community controls that were identified based on residential proximity to a case (neighbourhood controls). Neighbourhood controls were frequency matched to cases by neighbourhood (geographic proximity).

4.5.1.1 Case definitions

A case was defined as a person residing in the Local Health District of Hunter New England, Mid North Coast or Northern NSW with a laboratory confirmed *S.* Wangata infection with a specimen collection date between 1 November 2016 and 30 April 2017.

A control (Group 1 – STm control) was defined as a person residing in the Local Health District of Hunter New England, Mid North Coast or Northern NSW with a laboratory confirmed *Salmonella* Typhimurium (STm) infection with a specimen collection date between 1 November 2016 and 30 April 2017.

A control (Group 2 – neighbourhood control) was defined as a person residing in the neighbourhood (within 2 or 5 kilometres) of an enrolled case.

4.5.1.2 Exclusion criteria

Cases and STm controls were excluded from the study if they met any of the following criteria:

- They could not be reached after six attempts to contact them, spread over three days;
- They were unable to recall the date that their illness began (onset date);
- They were unable to answer questions or needed an interpreter;
- Another enteric pathogen other than *S.* Wangata or *S.* Typhimurium was detected in their stool specimen (co-infection);
- If there was another member of the household who had an onset of diarrhoea in the seven days prior to their onset;
- They had travelled more than 100 km from their home in the seven days prior to their onset; or
- They resided in an institution, such as an aged care facility.

Neighbourhood controls were excluded from the study if anyone in their household had diarrhoea or they had travelled more than 100 kilometres (km) from their home in the seven days prior to completing the questionnaire.

4.5.1.3 Identifying cases and controls

Notifiable conditions in NSW are electronically reported from laboratories to the NSW Notifiable Conditions Information Management System (NCIMS) for public health follow up by the corresponding LHD. Cases and STm controls were identified through the NCIMS system.

Neighbourhood controls were identified using geocoded national address files and ArcGIS mapping software. The Australian Department of Prime Minister and Cabinet released a publicly available PSMA Geocoded National Address File (G-NAF) in August 2016.[21] This file contains de-identified address information. We loaded the G-NAF file into the ArcMap application in ArcGIS Desktop Version 10.5 (Redlands, CA: Environmental Systems Research Institute). Cases' addresses were then geocoded and

entered as a layer in ArcMap. A 2 km radius was drawn around a cases' address using ArcMap and all the addresses from within the radius were extracted into an Excel file. Where the number of extracted addresses was less than 200, the process was repeated using a 5 km radius. A random number generator was used to randomly select 20 addresses.[22] A participant letter was sent to the households selected, along with a self-administered version of the interview questionnaire and a reply paid envelope. The participant letter also provided an option to complete the questionnaire online using Select Survey. Participants were asked to complete the questionnaire for the person in the household who had the next birthday.[23]

4.5.1.4 Sample size

We estimated that a minimum sample size of 140 (47 cases, 93 controls) was needed in order to detect an odds ratio of 2.8 with a two-sized confidence level of 95% and power of 80%. Since it was hypothesised that infections may be occurring from contact with native animals and the population exposure to native animals in Australia was unknown, ownership of a pet dog was used to calculate exposure. A hypothetical exposure of 64% among cases and 39% among controls was estimated using OpenEpi, Version 3.01, open source calculator.[24] The estimated exposure among cases was considered reasonable based on case responses to interviews from 2014–2016 (approx. 65% ownership) (unpublished data, OzFoodNet Hunter New England, 2016). Control exposure estimates were based on population dog ownership statistics from the 2013 Animal Health Alliance of Australia survey.[25]

Since neighbourhood controls were analysed separately, the sample size calculation was also applied to this group. An estimated response rate of 10% was used to quantify the number of questionnaires that would need to be sent.

4.5.1.5 Data collection and analysis

Cases and STm controls were interviewed via telephone by the OzFoodNet team at Hunter New England Population Health. Permission was given from North Coast Public Health to interview cases on their behalf. Neighbourhood controls completed a self-administered questionnaire either by mail or online using Select Survey.

Information was collected on clinical symptoms (for cases and STm controls only), environmental exposures at the person's residence, outdoor activities and direct and indirect animal contact (**Appendix 4.4**). Animal and environmental exposures were selected for inclusion in the questionnaire based on prior studies of environmental reservoirs of *Salmonella* and expert opinion from the Project Advisory Group

(**Appendix 4.1**).[5,9,12,17,26,27] For outbreak response purposes, information on foods consumed at commercial venues and from fresh produce markets were included for cases and STm controls, however this information was not included in the analysis.

Data were collected on paper forms, then entered and managed in a REDCap database hosted at Hunter New England Population Health.[28] Data were analysed separately for each control group using Stata version 14.1 (StataCorp LP, College Station, TX, USA). Data cleaning was undertaken to ensure the validity of the data. The following steps were included in the data cleaning process:

- Variables answered as "don't know" (999) were recoded as missing values;
- Continuous variables were reviewed for nonsensical data;
- Data were checked for duplicates;
- Inconsistent data were checked against the original questionnaire and amended where appropriate;
- Geographic variables (Local Government Area and rural/urban) were generated based on postcode information.

We mapped the distribution of cases in the study area using ArcMap in ArcGIS Desktop Version 10.5 (Redlands, CA: Environmental Systems Research Institute). Demographic and risk factor information for cases and controls were compared by calculating medians and ranges for continuous data, as well as frequencies and proportions for binary or categorical data.

The first step in the multivariable model building strategy included conducting univariable analyses on risk factor variables using logistic regression. Variables that had a positive association with illness and a p <0.25 in univariable analyses were selected for inclusion in multivariable analyses. Variables that had an inverse (protective) relationship with *S.* Wangata infection were not included in multivariable analyses as they would not contribute to answering the research question of which risk factors increased the risk of *S.* Wangata infection (clinical significance) and due to model parameter constraints (ratio of variables to observations).[29] An initial 'full' model was constructed with all variables selected from univariable analyses. Non-statistically significant variables (p <0.05) were removed sequentially from the model using a backward stepwise approach. Likelihood ratio tests were used to determine whether the removed variable was significantly contributing to the prediction of *S.* Wangata infection. The final 'main effects' models included potential confounders (age, sex and location) and statistically significant

exposures. Interactions were assessed in order to identify possible effect modification. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test and the area under the Receiver Operating Characteristic (ROC) curve.

Unconditional multivariable logistic regression models were conducted for each control group separately. Neighbourhood control data were also analysed using a random effects model in order to detect any geographic clustering in the data. Geographic clustering was not detected and thus a fixed effects model was used as the final model for this group. The model building steps applied in each model are provided in **Appendix 4.5** and **Appendix 4.6**.

4.5.2 Environmental Sampling

During case interviews, verbal consent was obtained to conduct environmental sampling at cases' residences. Participant information was given and written consent also obtained by Environmental Health Officers (EHOs) prior to beginning site inspections. EHOs collected water, soil and animal faecal matter samples from cases' residences using a standardised environmental sampling protocol developed by Kelly Simpson. As an extension of soil samples, fruit, vegetable or nut samples that had fallen on the ground were also collected. Where specific public areas (e.g. local parks, national parks) were identified through case interviews, additional environmental sampling was conducted by EHOs. The environmental sampling protocol was piloted with Environmental Health teams in each Local Health District prior to the commencement of the project (**Appendix 4.7**).

It was hypothesised that *S.* Wangata may be being carried in wildlife populations, making it difficult to detect through interviews as people are less likely to recall indirect exposures to wildlife. As an additional arm to the project, Kelly Simpson also arranged for a number of wildlife carers from the study region to provide animal faecal specimens for *Salmonella* testing.

Environmental samples were sent to the University of Sydney where they were cultured for *Salmonella* species by Kelly Simpson. Culture positive specimens were then forwarded to the Centre for Infectious Diseases and Microbiology – Public Health (CIDM-PH) at the Institute of Clinical Pathology and Medical Research (ICPMR) for serotyping. Culture and serotyping results were forwarded to the OzFoodNet team at Hunter New England Population Health. The OzFoodNet team contacted the cases and provided their environmental sampling results.

4.5.3 Whole genome sequencing

Human and environmental isolates that were positive for *S.* Wangata during the study period underwent whole genome sequencing at CIDM-PH. Bioinformatics analysis was still ongoing at the conclusion of the Masters of Applied Epidemiology (MAE) program, therefore whole genome sequencing (WGS) results have not been included in this thesis.

4.5.4 Ethical Review

The project was approved by the Hunter New England Human Research Ethics Committee (NSW HREC Reference: LNR/16/HNE/485), with site authorisation granted from the Hunter New England, Mid North Coast, Northern NSW and Western Sydney Local Health Districts. The project was also approved by the Australian National University Science & Medical Delegated Ethics Review Committee (Protocol: 2016/605).

In addition, animal ethics approval for the project was obtained from The University of Sydney Animal Ethics Committee.

4.6 Results

We received 76 notifications of human *S.* Wangata infections in the study region (Hunter New England, Mid North Coast and Northern NSW LHDs) during the study period (1 November 2016 to 30 April 2017). We were able to enrol 52 cases in the study, with cases following a similar geographical distribution to all notifications for that period (**Figure 4-2**, **Figure 4-3**).

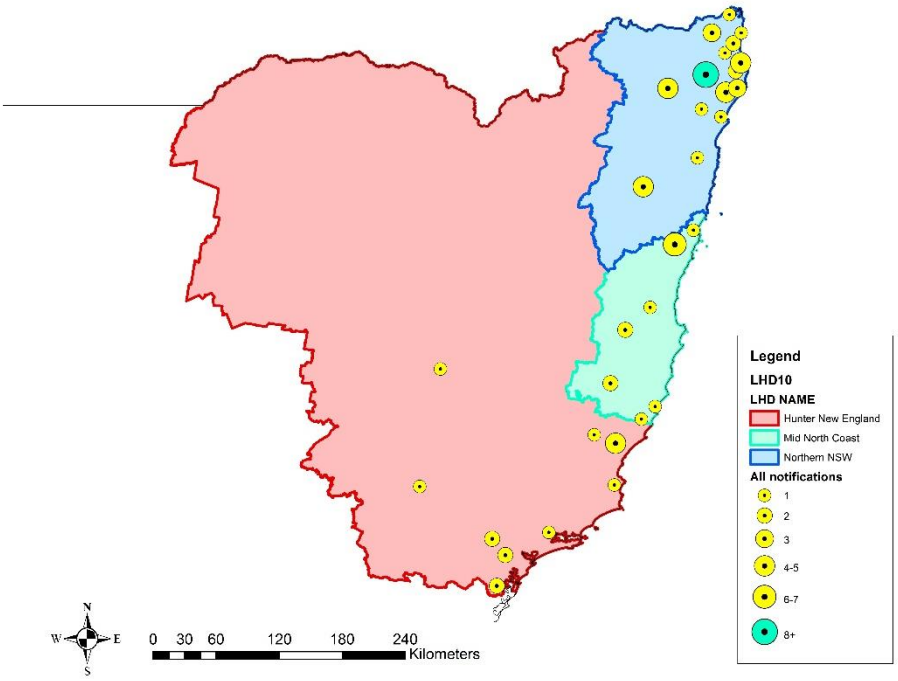

Figure 4-2: *Salmonella* Wangata notifications in the study region by postcode, November 2016–April 2017 (n=76)

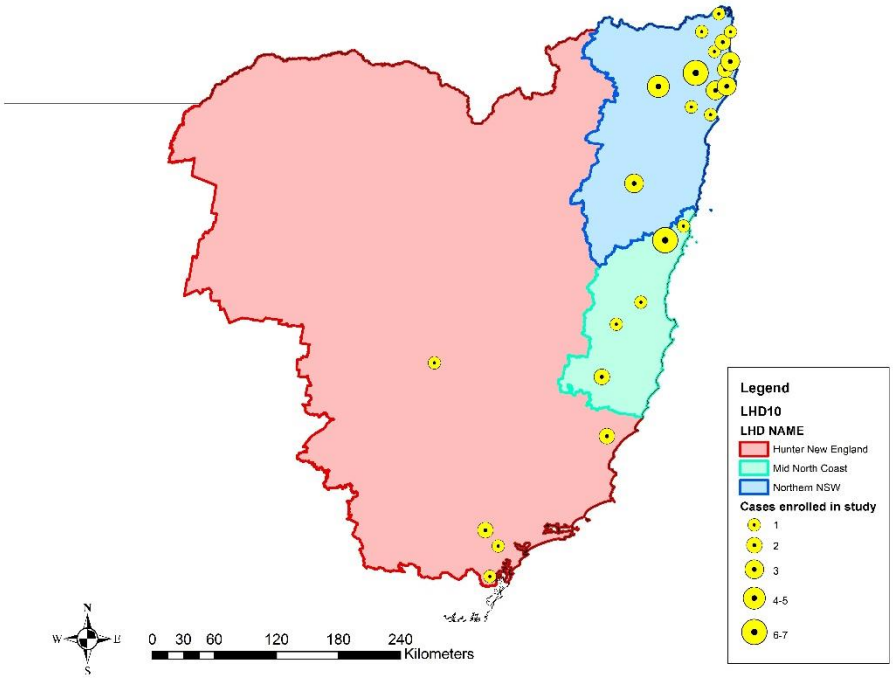

Figure 4-3: *Salmonella* Wangata cases enrolled in the study by postcode, November 2016–April 2017 (n=52)

4.6.1 Case-Control Study: Group 1 – *Salmonella* Typhimurium Controls

4.6.1.1 Descriptive analysis

Fifty-two cases and 55 STm controls were eligible and consented to be enrolled in the project (**Table 4-1**). Case ages ranged from 0–88 years, with a median of 54 years. Cases had a higher median age compared to STm controls due to a higher proportion of persons aged 65 years and over. Cases and STm controls were evenly distributed by sex and by geographic classification (rural/urban). The majority of cases were located in the Northern NSW LHD, followed by the Mid North Coast and Hunter New England LHDs (**Table 4-2**). The symptom profile was similar among cases and STm controls, although a higher proportion of cases were hospitalised (**Table 4-3**).

Table 4-1: Enrolment of cases and STm controls

Status	Cases	STm controls
Eligible and consented to be enrolled	52 (68%)	55 (79%)
Excluded (household diarrhoea, travel, or refusal)	12 (16%)	15 (21%)
Lost to follow up	12 (16%)	0 (0%)
Total	76 (100%)	70 (100%)

Table 4-2: Demographic characteristics of cases and STm controls

	Cases (n=52)	STm controls (n=55)	*p* value
Age			
Median (range)	54 years (0-88 years)	29 years (2-83 years)	0.049*
0-4 years	11 (21%)	11 (20%)	
5-14 years	5 (10%)	6 (11%)	
15-64 years	18 (35%)	31 (56%)	
65+ years	18 (35%)	7 (12%)	
Gender			
Male	28 (54%)	31 (56%)	0.794†
Female	24 (46%)	24 (44%)	
Local Health District			
Hunter New England	7 (13%)	33 (60%)	<0.001†
Mid North Coast	12 (23%)	8 (15%)	
Northern NSW	33 (63%)	14 (25%)	
Location			
Rural	14 (27%)	15 (27%)	0.968†
Urban	38 (73%)	40 (73%)	

**Two-sample Wilcoxon rank-sum (Mann-Whitney) test*
†X^2 test

Table 4-3: Clinical characteristics of cases and STm controls

	Cases (n=52)	STm controls (n=55)
Symptoms		
Diarrhoea	52 (100%)	55 (100%)
Abdominal pain	37 (71%)	47 (85%)
Bloody stool	15 (29%)	17 (31%)
Nausea	30 (58%)	38 (69%)
Vomiting	14 (27%)	29 (53%)
Fever	36 (69%)	47 (85%)
Headache	23 (44%)	29 (53%)
Lethargy	47 (90%)	50 (91%)
Muscle / body aches	19 (37%)	31 (56%)
Hospitalisation		
Admitted to hospital	21 (40%)	14 (25%)
Median hospital stay (range)	4 nights (1-10 nights)	2 nights (1-6 nights)

4.6.1.2 Univariable analysis

In the univariable analysis, variables with a moderate statistical association with *S*. Wangata infection (p <0.25) were selected for inclusion in the multivariable analysis. The only property exposure that showed a moderate statistical association with *S.* Wangata infection was growing fruit (p = 0.157) (**Table 4-4**). There were no statistically significant animal contact exposures among household pets (**Table 4-5**). Among livestock animal exposures, there was a moderate statistical association between indirect contact with horses (p = 0.084), although the proportion of cases exposed was low (12%) (**Table 4-6**). Among wildlife exposures, indirect contact with ibises (p = 0.027), seagulls (p = 0.248), bats/flying foxes (p = 0.010), native frogs (p = 0.033) and native lizards (p = 0.062) showed a statistical association (p <0.25) with *S.* Wangata infection and were included in the multivariable analysis (**Table 4-7**).

Table 4-4: Results from the univariable analysis of property and outdoor activity exposures among cases (n=52) and STm controls (n=55)

Exposure	Cases	Controls	Unadjusted OR (95% CI)	*p* value
Property				
Property size				
1/4 acre or less	33 (63%)	36 (65%)	(reference)	
> 1/4 acre to 5 acres	10 (19%)	7 (13%)	1.56 (0.53-4.57)	0.419
>5 acres	9 (17%)	12 (22%)	0.82 (0.31-2.19)	0.690
Private water supply	19 (37%)	22 (40%)	0.86 (0.40-1.89)	0.713
Grow fruit	25 (48%)	19 (35%)	1.75 (0.81-3.82)	0.157
Grow nuts	4 (8%)	6 (11%)	0.68 (0.18-2.56)	0.570
Grow vegetables / herbs	25 (48%)	23 (42%)	1.29 (0.60-2.76)	0.516
Eat home grown food	9 (18%)	9 (17%)	1.10 (0.40-3.05)	0.854
Contact with soil / grass	31 (60%)	34 (62%)	1.01 (0.71-1.45)	0.950
Outdoor activities				
Local park / playground	17 (33%)	21 (40%)	0.76 (0.34-1.70)	0.506
National parks / reserves	4 (8%)	4 (8%)	1.00 (0.24-4.23)	1.000
Natural water sources	16 (31%)	19 (35%)	0.82 (0.36-1.84)	0.629
Swam in a pool	12 (24%)	15 (27%)	0.82 (0.34-1.97)	0.659

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.

Table 4-5: Results from the univariable analysis of contact with household pets among cases (n=52) and STm controls (n=55)

Exposure	Cases	Controls	Unadjusted OR (95% CI)*	*p* value
Dog				
Direct contact	32 (62%)	37 (67%)	0.76 (0.33- 1.77)	0.528
Indirect contact	3 (6%)	3 (5%)	0.88 (0.15-5.05)	0.888
Cat				
Direct contact	12 (23%)	16 (30%)	0.77 (0.32-1.90)	0.576
Indirect contact	9 (17%)	5 (9%)	1.86 (0.56-6.17)	0.311
Pet bird				
Direct contact	3 (6%)	2 (4%)	1.71 (0.27-10.76)	0.565
Indirect contact	7 (13%)	4 (7%)	2.00 (0.55-7.31)	0.295
Pet chicken				
Direct contact	2 (4%)	8 (15%)	0.22 (0.04-1.08)	0.062
Indirect contact	6 (12%)	8 (15%)	0.65 (0.21-2.03)	0.457
Pet fish				
Direct contact	1 (2%)	1 (2%)	1.00 (0.06-16.45)	1.000
Indirect contact	3 (6%)	5 (9%)	0.60 (0.14-2.65)	0.501
Pet turtle				
Direct contact	0 (0%)	1 (2%)	n.a.	n.a.
Indirect contact	0 (0%)	0 (0%)	n.a.	n.a.
Pet snake				
Direct contact	0 (0%)	1 (2%)	n.a.	n.a.
Indirect contact	0 (0%)	0 (0%)	n.a.	n.a.
Pet lizard				
Direct contact	0 (0%)	2 (4%)	n.a.	n.a.
Indirect contact	0 (0%)	1 (2%)	n.a.	n.a.

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.
n.a. = not available.
**"No contact" used as reference category for odds ratio calculations of animal contact.*

Table 4-6: Results from the univariable analysis of contact with livestock animals among cases (n=52) and STm controls (n=55)

Exposure	Cases	Controls	Unadjusted OR (95% CI)*	*p* value
Cow				
Direct contact	2 (4%)	4 (7%)	0.48 (0.08-2.74)	0.407
Indirect contact	6 (12%)	8 (15%)	0.72 (0.23-2.24)	0.566
Sheep				
Direct contact	0 (0%)	4 (7%)	n.a.	n.a.
Indirect contact	0 (0%)	3 (6%)	n.a.	n.a.
Horse				
Direct contact	1 (2%)	3 (6%)	0.37 (0.04-3.69)	0.397
Indirect contact	6 (12%)	1 (2%)	6.67 (0.77-57.52)	0.084
Goat				
Direct contact	1 (2%)	2 (4%)	0.51 (0.04-5.80)	0.587
Indirect contact	0 (0%)	0 (0%)	n.a.	n.a.
Alpaca				
Direct contact	0 (0%)	1 (2%)	n.a.	n.a.
Indirect contact	0 (0%)	0 (0%)	n.a.	n.a.
Pig				
Direct contact	1 (2%)	1 (2%)	1.04 (0.06-17.08)	0.978
Indirect contact	0 (0%)	2 (4%)	n.a.	n.a.
Chicken				
Direct contact	0 (0%)	2 (4%)	n.a.	n.a.
Indirect contact	1 (2%)	2 (4%)	0.49 (0.04-5.58)	0.566

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.
n.a. = not available.
**"No contact" used as reference category for odds ratio calculations of animal contact.*

Table 4-7: Results from the univariable analysis of contact with wildlife among cases (n=52) and STm controls (n=55)

Exposure	Cases	Controls	Unadjusted OR (95% CI)*	*p* value
Kangaroo / wallaby				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	13 (25%)	13 (24%)	1.08 (0.45-2.61)	0.869
Quoll				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	2 (4%)	0 (0%)	n.a.	n.a.
Possum				
Direct contact	0 (0%)	1 (2%)	n.a.	n.a.
Indirect contact	8 (15%)	13 (24%)	0.56 (0.21-1.49)	0.245
Bandicoot				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	9 (18%)	8 (15%)	1.21 (0.43-3.41)	0.725
Ibis				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	16 (31%)	7 (13%)	3.05 (1.13-8.18)	0.027
Seagull				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	11 (21%)	7 (13%)	1.84 (0.65-5.18)	0.248
Duck				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	16 (31%)	16 (29%)	1.08 (0.47-2.48)	0.850
Native bird				
Direct contact	1 (2%)	2 (4%)	0.55 (0.04-7.03)	0.646
Indirect contact	41 (79%)	42 (76%)	1.07 (0.41-2.80)	0.884
Bat / flying fox				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	32 (65%)	21 (40%)	2.87 (1.28-6.42)	0.010
Native frog				
Direct contact	0 (0%)	1 (2%)	n.a.	n.a.
Indirect contact	25 (48%)	15 (27%)	2.41 (1.07-5.39)	0.033
Native snake				
Direct contact	0 (0%)	1 (2%)	n.a.	n.a.
Indirect contact	17 (33%)	16 (29%)	1.15 (0.51-2.63)	0.734
Native lizard				
Direct contact	0 (0%)	2 (4%)	n.a.	n.a.
Indirect contact	34 (65%)	25 (45%)	2.12 (0.96-4.64)	0.062

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.
n.a. = not available
**"No contact" used as reference category for odds ratio calculations of animal contact*

4.6.1.3 Multivariable analysis

In the multivariable analysis, indirect contact with bats/flying foxes (OR: 2.63 [1.11-6.20], $p = 0.028$) was statistically associated ($p < 0.05$) with *S.* Wangata infection after adjusting for age, sex and location. Indirect contact with native frogs (OR: 2.48 [1.00-6.13], $p = 0.049$) was just within the significance limit ($p < 0.05$) and also indicated an association with *S.* Wangata infection. Whilst age was statistically significant in the model ($p = 0.018$) its association with *S*. Wangata infection was minor (OR: 1.02 [1.00-1.04]). Sex and location were not statistically significant in the model, however these variables were retained as possible confounders.

Table 4-8: Results from the multivariable analysis of environmental and animal risk factors among cases (n=52) and STm controls (n=55)

Exposure	Adjusted OR (95% CI)*	*p* value
Age	1.02 (1.00-1.04)	0.018
Sex		
Male	(reference)	
Female	1.08 (0.45-2.55)	0.866
Location		
Urban	(reference)	
Rural	0.98 (0.37-2.61)	0.968
Bat / flying fox		
Direct contact	n.a	n.a
Indirect contact	**2.63 (1.11-6.20)**	**0.028**
Native frog		
Direct contact	n.a	n.a
Indirect contact	**2.48 (1.00-6.13)**	**0.049**

**"No contact" used as reference category for odds ratio calculations of animal contact*

4.6.2 Case-Control Study: Group 2 – Neighbourhood Controls

4.6.2.1 Descriptive analysis

We enrolled 52 cases during the study period (**Table 4-9**). Questionnaires were sent to 20 neighbourhood control households per case, with a total of 1040 questionnaires mailed. We received 220 (21%) completed control questionnaires, however 83 were excluded from the study due to either recording having a household member with diarrhoea or having travelled more than 100km from their residence in the 7 days prior to completing the questionnaire (**Table 4-9**). Cases and controls were similarly distributed between the three LHDs, with the majority of participants residing in Northern NSW (**Table 4-10**). There were some differences in age distribution between cases and controls, with controls having a higher proportion of participants in the 15-64 years and the 65 years and over age groups (**Table 4-10**).

Table 4-9: Enrolment of cases and neighbourhood controls

Status	Cases	Neighbourhood controls
Eligible and consented to be enrolled	52 (68%)	137 (13%)
Excluded (household diarrhoea or travel)	12 (16%)	83 (8%)
Lost to follow up	12 (16%)	820 (79%)
Total	**76 (100%)**	**1040 (100%)**

Table 4-10: Demographic characteristics of cases and neighbourhood controls

	Cases (n=52)	Controls (n=137)	*p* value
Age			
0-4 years	11 (21%)	2 (1%)	<0.001*
5-14 years	5 (10%)	5 (4%)	
15-64 years	18 (35%)	68 (50%)	
65 years and over	18 (35%)	62 (45%)	
Local Health District			
Hunter New England	7 (13%)	12 (9%)	0.458†
Mid North Coast	12 (23%)	26 (19%)	
Northern NSW	33 (63%)	99 (72%)	

**Fisher's exact*
†X^2 test

4.6.2.2 Univariable analysis

A number of environmental and animal exposures showed a moderate association (p <0.25) with *S*. Wangata infection in univariable analyses. The outdoor activities of visiting a local park or playground (p = 0.022) and swimming in a pool (p = 0.059) in the seven days prior to symptom onset/questionnaire completion were included in the multivariable analysis (**Table 4-11**). Among household pets and livestock animals, direct contact with dogs (p = 0.186) and indirect contact with cats (p = 0.009) and horses (p = 0.012) were included in the multivariable analysis (**Table 4-12**, **Table 4-13**). Among wildlife, indirect contact with kangaroos/wallabies (p = 0.017), possums (p = 0.111), bandicoots (p = 0.030), ibises (p = 0.004), seagulls (p = 0.001), ducks (p = 0.015), native birds (p <0.001), bats/flying foxes (p <0.001), native frogs (p <0.001), native frogs (p <0.001), native snakes (p <0.001) and native lizards (p <0.001) were statistically significant (p <0.25) and included in the multivariable analysis (**Table 4-14**).

Table 4-11: Results from the univariable analysis of property and outdoor activity exposures among cases (n=52) and neighbourhood controls (n=137)

Exposure	Cases	Controls	Unadjusted OR (95% CI)	*p* value
Property				
Property size				
1/4 acre or less	33 (63%)	87 (64%)	(reference)	
> 1/4 acre to 5 acres	10 (19%)	22 (16%)	1.20 (0.51-2.80)	0.676
>5 acres	9 (17%)	26 (19%)	0.91 (0.39-2.15)	0.834
Private water supply	19 (37%)	50 (37%)	0.98 (0.50-1.90)	0.950
Grow fruit	25 (48%)	68 (50%)	0.91 (0.48-1.73)	0.779
Grow nuts	4 (8%)	25 (19%)	0.36 (0.12-1.10)	0.073
Grow vegetables / herbs	25 (48%)	77 (57%)	0.70 (0.37-1.33)	0.271
Eat home grown food	9 (18%)	59 (44%)	0.29 (0.13-0.64)	0.002
Contact with soil / grass	31 (60%)	100 (74%)	1.01 (0.98-1.04)	0.635
Outdoor activities				
Local park / playground	17 (33%)	23 (17%)	2.37 (1.14-4.95)	0.022
National parks / reserves	4 (8%)	14 (11%)	0.71 (0.22-2.26)	0.560
Natural water sources	16 (31%)	33 (25%)	1.35 (0.66-2.73)	0.410
Swam in a pool	12 (24%)	16 (12%)	2.23 (0.97-5.12)	0.059

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.

Table 4-12: Results from the univariable analysis of contact with household pets among cases (n=52) and neighbourhood controls (n=137)

Exposure	Cases	Controls	Unadjusted OR (95% CI)*	*p* value
Dog				
Direct contact	32 (62%)	65 (50%)	1.59 (0.80-3.17)	0.186
Indirect contact	3 (6%)	10 (8%)	0.97 (0.24-3.94)	0.967
Cat				
Direct contact	12 (23%)	28 (24%)	1.13 (0.51-2.50)	0.756
Indirect contact	9 (17%)	5 (4%)	4.76 (1.48-15.32)	0.009
Pet bird				
Direct contact	3 (6%)	14 (12%)	0.46 (0.13-1.68)	0.240
Indirect contact	7 (13%)	10 (9%)	1.50 (0.53-4.21)	0.442
Pet chicken				
Direct contact	2 (4%)	7 (6%)	0.60 (0.12-2.99)	0.531
Indirect contact	6 (12%)	10 (9%)	1.25 (0.43-3.67)	0.679
Pet fish				
Direct contact	1 (2%)	10 (9%)	0.19 (0.02-1.53)	0.118
Indirect contact	3 (6%)	9 (8%)	0.63 (0.16-2.44)	0.506
Pet turtle				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	0 (0%)	0 (0%)	n.a.	n.a.
Pet snake				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	0 (0%)	0 (0%)	n.a.	n.a.
Pet lizard				
Direct contact	0 (0%)	2 (2%)	n.a.	n.a.
Indirect contact	0 (0%)	1 (1%)	n.a.	n.a.

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.
n.a. = not available.
**"No contact" used as reference category for odds ratio calculations of animal contact.*

Table 4-13: Results from the univariable analysis of contact with livestock animals among cases (n=52) and neighbourhood controls (n=137)

Exposure	Cases	Controls	Unadjusted OR (95% CI)*	*p* value
Cow				
Direct contact	2 (4%)	7 (6%)	0.72 (0.14-3.61)	0.690
Indirect contact	6 (12%)	8 (6%)	1.89 (0.62-5.77)	0.262
Sheep				
Direct contact	0 (0%)	1 (1%)	n.a.	n.a.
Indirect contact	0 (0%)	1 (1%)	n.a.	n.a.
Horse				
Direct contact	1 (2%)	9 (7%)	0.29 (0.04-2.33)	0.242
Indirect contact	6 (12%)	1 (1%)	15.47 (1.81-132.09)	0.012
Goat				
Direct contact	1 (2%)	1 (1%)	2.39 (0.15-38.99)	0.540
Indirect contact	0 (0%)	1 (1%)	n.a.	n.a.
Alpaca				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	0 (0%)	2 (2%)	n.a.	n.a.
Pig				
Direct contact	1 (2%)	0 (0%)	n.a.	n.a.
Indirect contact	0 (0%)	1 (1%)	n.a.	n.a.
Chicken				
Direct contact	0 (0%)	4 (3%)	n.a.	n.a.
Indirect contact	1 (2%)	13 (10%)	0.16 (0.02-1.27)	0.083

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.
n.a. = not available.
**"No contact" used as reference category for odds ratio calculations of animal contact.*

Table 4-14: Results from the univariable analysis of contact with wildlife among cases (n=52) and neighbourhood controls (n=137)

Exposure	Cases	Controls	Unadjusted OR (95% CI)*	*p* value
Kangaroo / wallaby				
Direct contact	0 (0%)	1 (1%)	n.a.	n.a.
Indirect contact	13 (25%)	13 (10%)	2.82 (1.20-6.61)	0.017
Quoll				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	2 (4%)	0 (0%)	n.a.	n.a.
Possum				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	8 (15%)	9 (7%)	2.28 (0.83-6.29)	0.111
Bandicoot				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	9 (18%)	8 (7%)	3.08 (1.12-8.51)	0.030
Ibis				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	16 (31%)	15 (12%)	3.23 (1.45-7.18)	0.004
Seagull				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	11 (21%)	4 (3%)	7.98 (2.41-26.45)	0.001
Duck				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	16 (31%)	18 (15%)	2.62 (1.21-5.67)	0.015
Native bird				
Direct contact	1 (2%)	4 (3%)	2.28 (0.23-22.39)	0.481
Indirect contact	41 (79%)	28 (23%)	13.33 (5.92-29.97)	<0.001
Bat / flying fox				
Direct contact	0 (0%)	0 (0%)	n.a.	n.a.
Indirect contact	32 (65%)	18 (15%)	10.98 (5.07-23.76)	<0.001
Native frog				
Direct contact	0 (0%)	2 (2%)	n.a.	n.a.
Indirect contact	25 (48%)	22 (18%)	4.12 (2.02-8.42)	<0.001
Native snake				
Direct contact	0 (0%)	1 (1%)	n.a.	n.a.
Indirect contact	17 (33%)	10 (9%)	5.15 (2.16-12.28)	<0.001
Native lizard				
Direct contact	0 (0%)	2 (2%)	n.a.	n.a.
Indirect contact	34 (65%)	18 (15%)	10.49 (4.91-22.45)	<0.001

Percentages may not reflect total number of cases/controls due to missing data.
P value <0.25 was used as a test of significance in univariable analyses to determine the selection of variables for inclusion in the multivariable analysis. Variables included in the multivariable analysis are shaded.
n.a. = not available.
**"No contact" used as reference category for odds ratio calculations of animal contact.*

4.6.2.3 Multivariable analysis

In the multivariable analysis, indirect contact with bats/flying foxes (OR: 7.55 [2.63-21.71]) and indirect contact with native birds (OR: 5.54 [2.05-14.95]) were statistically associated (p <0.05) with *S.* Wangata infection after adjusting for age group and location.

Table 4-15: Results from multivariable analysis of environmental and animal risk factors among cases (n=52) and neighbourhood controls (n=137)

Exposure	Adjusted OR (95% CI)*	*p* value
Age Group		
0-4 years	(reference)	
5-14 years	0.08 (0.01-1.02)	0.051
15-64 years	0.06 (0.01-0.41)	0.004
65+ years	0.08 (0.01-0.56)	0.011
Location		
Urban	(reference)	
Rural	2.04 (0.65-6.34)	0.220
Native bird		
Direct contact	2.21 (0.19-25.32)	0.525
Indirect contact	**5.54 (2.05-14.95)**	**0.001**
Bat/ flying fox		
Direct contact	n.a	n.a.
Indirect contact	**7.55 (2.63-21.71)**	**<0.001**

n.a. = not available.
**"No contact" used as reference category for odds ratio calculations of animal contact*

4.6.3 Environmental sampling

We collected a total of 207 environmental specimens from the residences of 26 cases who provided consent for sampling (**Table 4-16**). We collected 70 animal faecal specimens, including 33 specimens from household pets, 10 from livestock animals and 27 from wildlife. Soil samples (n=82) were taken from areas of likely human interaction at cases' residences (e.g. vegetable gardens) and comprised of soil, compost, leaf litter and fallen fruit/nut specimen types. Water samples (n=54) were taken from private water supplies (e.g. rainwater tanks) and any accessible bodies of water on the property (e.g. ponds, dams). The median time from a case's reported onset of diarrhoea to the date of environmental sample collection was 32 days (range 18–59 days). Wildlife carers in the region also submitted 48 animal faecal specimens from 24 different species, including 17 birds, 23 mammals and 8 reptiles (personal communication, Kelly Simpson, University of Sydney, 2017).

Salmonella was detected in 17 specimens in total: 9 from cases' residences and 8 from wildlife carers. *S.* Wangata was detected in 5 specimens from cases' residences, including 3 wildlife faecal specimens, 1 pet dog specimen and 1 compost specimen (**Table 4-17**). *S.* Wangata was also detected in 4 specimens from wildlife carers, including 2 green sea turtles, a pelican and a black swan (**Table 4-18**).

For cases E and G where environmental sampling identified a positive *Salmonella* infection in a pet dog, we enquired whether these animals had experienced any illness. Both cases reported that the dogs had been healthy and had not experienced any illness prior to sample collection.

Table 4-16: Summary of environmental specimens collected

Specimen types	Collected from cases' residences	Collected by wildlife carers
Total case residences / wildlife carers	26	9
Soil / compost / leaf litter specimens / fruit or nuts fallen on the ground	82	-
Water specimens	54	-
Animal faecal specimens	70	48
Other specimens	1	-
Total specimens collected and cultured	207	48
Salmonella species detected	9	8

Table 4-17: Summary of environmental samples from cases' residences by *Salmonella* serovar

Case ID	Specimen type	Description	*Salmonella* serovar
Case A	Compost	No further description	*S*. Kiambu
Case B	Faeces	Wildlife	*S*. Wangata
Case C	Compost	Grass clippings and soil	*S*. Wangata
Case D	Soil	Suspected animal diggings	*S*. Birkenhead
Case D	Soil	Suspected animal diggings	*S*. Birkenhead
Case E	Faeces	Pet dog	*S*. Wangata
Case F	Faeces	Wildlife	*S*. Wangata
Case F	Faeces	Wildlife	*S*. Wangata
Case G	Faeces	Pet dog	*S*. Birkenhead

Table 4-18: Summary of environmental samples from wildlife carers by *Salmonella* serovar

No.	Animal	Description	*Salmonella* serovar
1	Green sea turtle	In care – since released	*S*. Wangata
2	Green sea turtle	In care – since released	*S*. Wangata
3	Wombat	Free ranging on carers property	*S*. Kottbus
4	Pelican	In care – brought in with swan	*S*. Wangata
5	Black Swan	In care – brought in with pelican	*S*. Wangata
6	Tawny Frogmouth	In care – possible rat lung worm	*S*. Chailey
7	Gould long eared bat	In care	*S*. Bovismorbificans
8	Magpie	Wild – opportunistically collected	*S*. Bovismorbificans

4.7 Discussion

Salmonella bacteria are ubiquitous and can survive in a range of hosts and environments. However, research on environmental pathways for human infection with *Salmonella* in Australia are limited.[17,27] In this study, we examined environmental risk factors for *S.* Wangata infections in north east NSW and conducted targeted environmental sampling at cases' residences to identify *S.* Wangata in the environment.

The associations between infection and indirect contact with bats or flying foxes, native birds and native frogs in the final models suggest that *S.* Wangata may have a reservoir in native wildlife populations in Australia. Bats are known reservoirs for viral pathogens, however their carriage of bacterial, enteric pathogens is less well understood in Australia. Our investigation identified *Salmonella* Bovismorbificans in a sample from a Gould long eared bat that was in care in the study region. Recent studies from other countries have also detected *Salmonella* and other bacterial pathogens in fruit bats and insectivorous bat species.[30-34] Bats may be a unique transmitter of bacterial pathogens due to their ability to travel over long distances.[31] Native birds and native frogs have been associated with human infection with *Salmonella* in previous studies in Australia.[17,27,35] Our investigation identified *S.* Wangata in aquatic birds, *S.* Bovismorbificans in a Magpie and *S.* Chailey in a Tawny Frogmouth. Native bird populations are at the forefront of the human/wildlife interface and may be involved in bi-directional *Salmonella* transmission.[5,9] Native frogs have been associated with indirect transmission to humans through contaminated environments and water, particularly in northern tropical climates in Australia.[17,35] Previous studies have indicated that direct contact with animals is not necessary for infection and the ability of *Salmonella* to survive for long periods in the environment supports the plausibility of indirect transmission pathways.[27]

Low levels of exposure to household pets and livestock animals among cases and controls indicates that these animals are unlikely sources of human infection. The only household pet that had a high exposure level among cases was pet dogs (62% direct contact). Contact with pet dogs was not statistically significant in univariable analyses in both models, reflecting high exposure levels among both case and control groups. Whilst pet dog contact was not a statistically significant environmental risk factor in the case-control study, *Salmonella* was detected in two pet dog faecal samples collected from different case residences. One of these samples was positive for *S.* Wangata, indicating a possible transmission pathway for this serovar. Dogs may act as vectors of environmental *Salmonella* serovars due to their interactions with both environments and humans. The prevalence of *Salmonella* carriage in dogs is difficult to determine due to possible subclinical infections. In our investigation, both dogs with a positive *Salmonella*

infection showed no signs of illness. Lowden *et al* assessed subclinical *Salmonella* carriage among dogs in the United Kingdom in 2013 and found that prevalence was very low (0.23% [95% CI: 0.006%–1.27%]).[36] However, due to the geographical variation of *Salmonella* in the environment this study may not reflect the Australian context. There have been no recent studies assessing the prevalence of subclinical *Salmonella* carriage among dogs in Australia.

Property exposures were not statistically significantly associated with *S.* Wangata infection. Cases were not more likely to live in a rural area or on a larger property compared to control groups. This suggests an environmental reservoir that is found in both rural and urban areas and supports the hypothesis that livestock animals are an unlikely source of infection for this serovar. Cases were not more likely to use a private water supply compared to control groups. In addition, *Salmonella* was not detected in any of the water samples collected from cases' residences. These findings are dissimilar to previous studies that have implicated drinking water as a vehicle of infection for *Salmonella*.[27,35] Cases were not more likely to consume home grown foods or have contact with soil or grass compared to control groups. However, the *Salmonella* serovars Wangata, Kiambu and Birkenhead were detected from soil samples collected from cases' residences, indicating that contaminated soil may be a transmission pathway. Whilst property exposures were not associated with *S.* Wangata infection in our study, the detection of positive environmental samples in from cases' properties suggests that further investigation of the interaction between cases and their environments is needed.

Outdoor activities were not identified as significant environmental risk factors in our study. Visiting a local park/playground or visiting a national/park or reserve were not statistically associated with *S.* Wangata infection in univariable and multivariable analyses. In addition, the odds of having contact with natural water sources (e.g. rivers, lakes, beaches) or swimming in a pool were not statistically significantly higher among cases compared to control groups, although recreational water contact has previously been implicated in *Salmonella* outbreaks.[16] Measuring environmental exposures through outdoor activities would be better supported by targeted environmental sampling, as has been conducted in previous studies.[12] Due to poor recall in relation to specific outdoor exposure locations and accessibility constraints we were unable to conduct environmental sampling for outdoor activity exposures in this investigation.

4.7.1 Limitations

There were a number of strengths and limitations associated with the case-control study. Cases were selected from surveillance data of laboratory-confirmed *S.* Wangata infections and as such only represent a proportion of the total number of cases occurring in the community. It has been estimated that for every notified case of *Salmonella*, an additional 7 cases (95% CI 4–16 cases) occur in the community.[37] By adopting a case-case methodology and selecting our first control group from a comparable 'diseased' population, we were able to reduce possible recall bias.[18,19] Interviewer bias was also minimised in our study through the use of a structured questionnaire and the administration of all telephone questionnaires by two interviewers from Hunter New England Population Health. The interviewers shared an office and regularly discussed administration of the questionnaire to ensure consistency.

STm controls were frequency matched to cases by age group to ensure a similar age distribution for comparison. However, due to low numbers of STm notifications during the study period we were unable to obtain the expected 2:1 ratio of controls to cases, particularly in some age groups. *S.* Wangata infections have historically affected an older population compared to other *Salmonella* serovars (unpublished data, NSW Notifiable Conditions Information Management System, 2016). This was apparent in our study, with 35% of cases aged 65 years and over. Age was adjusted for in the multivariable model, however due to the small sample size statistical precision may have been lost in relation to age.

Cases were not matched to STm controls by geographical criteria, such as postcode, Local Government Area (LGA) or Local Health District (LHD). Due to the number of expected notifications during the study period, it was not considered feasible to match on these categories. A rural/urban classification based on the Australian Bureau of Statistics (ABS) remoteness structure was included in the analysis to account for geographical variation.

We frequency matched cases and neighbourhood controls by neighbourhood (2km or 5km radius around a cases' residence). We did not match this group by age, but attempted to reduce any bias in age distribution by requesting that participants complete the questionnaire for the person in the household who had the next birthday.[23] This method relies on self-randomisation within households and may have been subject to inaccurate reporting by respondents. We did not collect information on household size or apply any weighting in this regard. Our data may have been influenced by single-person households, which reduced the proportion of responses for younger persons (<15 years).

Due to an oversight in the neighbourhood control questionnaire, we did not collect information on sex for this control group. Historically, *S.* Wangata cases have been equally distributed by sex (unpublished data, NSW Notifiable Conditions Information Management System, 2011–2015). This was also true for cases enrolled in the study (54% Male). As a comparison, we removed sex from the STm control multivariable model and found that it was not significantly contributing to the prediction of *S.* Wangata infection (Likelihood-ratio $X^2 = 0.03$, $p = 0.866$). Based on the next-birthday participant selection method, demographic characteristics were assumed to be randomly distributed among households.

Our study was strengthened by the inclusion of two control groups. Using controls from a diseased population (STm controls) affords benefits in relation to recall bias, however exposures in this group may be unrepresentative of the general population. Using controls from the general population (neighbourhood controls) ensures representativeness, however recall may differ between cases and this control group. Having both control groups enabled us to more accurately interpret environmental risks for *S.* Wangata infection.

We encountered some limitations in relation to the collection of environmental samples in our study. Environmental samples were collected a median of 32 days after a case's reported onset of diarrhoea, which may have reduced our ability to detect *Salmonella*. Whilst *Salmonella* can survive well in dry environmental conditions, rainfall between the date of exposure and the date of specimen collection may have removed contaminated sources. In addition, our study was impacted by major flooding in the Lismore area in March 2017. As a result of the flooding, Environmental Health Officers were unable to access some properties or collection was delayed. In addition, flooding reduced the participation of wildlife carers in the study (personal communication, Kelly Simpson, University of Sydney, 2017) and therefore reduced the number of environmental samples received.

4.8 Conclusion and recommendations

Our study investigated environmental risk factors and environmental sources for infection with *S.* Wangata. We found associations between infection and indirect contact with bats or flying foxes, native birds and native frogs in the final models. We also detected *S.* Wangata in a soil specimen, a pet dog faecal specimen and other wildlife faecal specimens. Further definition on the relatedness between human and environmental isolates may be provided through whole genome sequencing and bioinformatics analysis, which is currently underway.

Our results indicate that *S.* Wangata may have a reservoir in native wildlife populations in Australia. Further research into the prevalence of *Salmonella* among wildlife populations, particularly native bats, birds and frogs, would be useful to enhance our understanding of environmental sources. In addition, bi-directional transmission pathways should be assessed to identify possible human–environmental control measures to reduce the introduction of the bacteria in wildlife populations.

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Appendix 4.1: *Salmonella* Wangata Project – Project Advisory Group

Project Advisory Group (alphabetical order by surname)

Name	Position	Organisation
Mr Greg Bell	Assistant Director, Public Health	North Coast Public Health
Ms Julie Collins	Epidemiology Registrar / MAE Scholar	Hunter New England Population Health & Australian National University
Prof David Durrheim	Director, Health Protection	Hunter New England Population Health (Chair)
Mr James Flint	Epidemiologist	Hunter New England Population Health
Dr Grant Hill-Cawthorne	Senior Lecturer	Marie Bashir Institute, University of Sydney
Dr Kirsty Hope	Manager, Enteric and Zoonotic Diseases	Health Protection NSW, NSW Ministry of Health
Mr Peter Howard	Senior Scientific Officer in Charge, NSW Enteric Reference Laboratory	Centre for Infectious Diseases and Microbiology - Public Health
Mr Tony Kohlenberg	Senior Environmental Health Officer	North Coast Public Health
Ms Kerryn Lawrence	Senior Environmental Health Officer	North Coast Public Health
Mrs Kim Lilly	Research Officer	Hunter New England Population Health
Dr Siobhan Mor	Senior Lecturer	Department of Veterinary Science, University of Sydney
Mr Philippe Porigneaux	Environmental Health Manager	Hunter New England Population Health
Ms Kelly Simpson	PhD Candidate	Department of Veterinary Science, University of Sydney
Prof Vitali Sintchenko	Director, CIDM Public Health	Centre for Infectious Diseases and Microbiology
Prof Michael Ward	Chair of Veterinary Public Health & Food Safety	Department of Veterinary Science, University of Sydney
Dr Anke Wiethoelter	Lecturer	Faculty of Veterinary and Agricultural Sciences, University of Melbourne

Appendix 4.2: Targeted Literature Review

Aim of literature review and research question

In Australia, approximately 72% of *Salmonella* infections are estimated to be transmitted via food.[1] There is considerable research dedicated to foodborne transmission of *Salmonella*, however research on animal or environmental transmission pathways is limited. I conducted a focused literature review to answer the research question:

What is the prevalence of Salmonella in wildlife and environmental sources in Australia?

Methods

PubMed was used to search for publications using the search terms listed in Table 1. Searches were limited to articles in the English language and those with full text available. Fifty-nine articles were found using the terms '*Salmonella*' and 'Australia' and 'wildlife' or 'native animal'. It was decided to also conduct a specific search for known *Salmonella* carriers reptiles (n=14) and birds (n=11). The terms 'soil' and 'water' were used to search for environmental sources of *Salmonella*. Single case reports, duplicate studies, studies conducted outside of Australia and those not addressing the research question were excluded. Fourteen abstracts were considered useful in addressing the research question and articles were reviewed in full.

Table 1. Results of literature search using PubMed

Search terms	Number of records
Salmonella	52566
Salmonella and Australia	1010
Salmonella and Australia AND wildlife OR native animal	59
Salmonella AND Australia AND reptile	14
Salmonella AND Australia AND bird	11
Salmonella AND Australia AND soil	15
Salmonella AND Australia AND water	37

Table 2. Summary of studies reviewed for targeted literature review

No.	Authors	Reference Details	Objectives	Methods	Key results
1	Dolejska M, Masarikova M, Dobiasova H *et al*.	Journal of Antimicrobial Chemotherapy, 2016; 71: 63-70.	To estimate the prevalence of *Salmonella* and carbapenemase-producing Enterobacteriaceae (CPE) in silver gulls in south-east Australia.	- 504 clocal samples collected from gull chicks at 3 nesting colonies in south-east Australia in October 2012 were tested for *Salmonella* and CPE.	- 66 isolates were positive for *Salmonella* enterica; 56 of these isolates were from the Five Islands colony off the coast of Wollongong. - Garbage depot linked as a food source for gulls, indicating possible human to wildlife *Salmonella* transmission.
2	Iveson J, Bradshaw S, How R, Smith D.	Epidemiology & Infection, 2014; 142(11): 2281-2296.	To document the occurrence and distribution of *Salmonella* serovars in humans and native wildlife in Western Australia and the islands of Wallacea.	- Human infection data from 1985-2000 collected from NEPSS - Samples from wildlife collected from 17 islands in the Wallacea region (1989-1993). 11 islands sampled off the WA coast during the same time period. - Samples targeted vertebrate species only.	- Large range of *Salmonella* serovars detected in wildlife. - Limitations around methods and timeframe of sample collection.

No.	Authors	Reference Details	Objectives	Methods	Key results
3	Staff M, Musto J, Hogg G, Janssen M, Rose K.	Emerging Infectious Diseases, 2012; 18(7): 1159-1162.	Outbreak investigation of *Salmonella enterica* var. Java in North Sydney.	- Case-control study examining risk factors (n=48). - Faecal and cloacal samples from 261 free-ranging animals. Samples tested for *Salmonella*.	- 34 isolates of *S. enterica* var. Java identified, with the majority coming from a native marsupial species: the long-nosed bandicoot. - *S. enterica* var. Java isolated from playground sand, indicating human exposure pathway. Animal isolates indistinguishable from human isolates.
4	Iveson J, Shellam G, Bradshaw S *et al*.	Epidemiology & Infection, 2009; 137: 858-870.	To compare the occurrence of *Salmonella* enterica infections in wildlife in Antarctica/sub-Antarctic islands with marine and terrestrial fauna off the West Australian coast.	- Faecal samples and swabs collected from Antarctica over 4 years, from 1982-1986. - Faecal/cloacal samples collected from marine animals off the coast of WA. Samples also collected from reptiles and marsupials from island populations in WA.	- Birds may act as asymptomatic carriers and intermittent excretors of *Salmonella*. - Human to animal transmission may occur through unregulated discharge of contaminated waste from cruise ships and shipping activities (cause-and-effect relationship not proven).

No.	Authors	Reference Details	Objectives	Methods	Key results
5	Ashbolt R, Kirk M.	Epidemiology & Infection, 2006; 134: 1257-1265.	To examine transmission pathways for *Salmonella* Mississippi in Tasmania.	- Case-control study conducted for 12 months (2001 to 2002). - Controls identified from a previously conducted study using random digit dialling. - Exposures included food, water, travel, behaviours and demographic information. Indirect and direct contact with pets, livestock animals and native animals also measured.	- 59 cases of *S.* Mississippi enrolled and 219 controls enrolled. - In multivariable analysis, drinking untreated water, exposure to native bird environments, living on/visiting a farm, travel overnight within the state, exposure to pet faeces and sucking fingers/thumbs or biting fingernails were associated with illness.
6	Thomas A, Forbes-Faulkner J, Speare R, Murray C.	Journal of Wildlife Diseases, 2001; 37(2): 229-238.	To document the *Salmonella* serovars present in wildlife populations in northern Queensland.	- 233 wildlife samples (representing 25 different species) collected by the Oonoonba Veterinary Reference Laboratory over a 20 year period from 1978-1998). - Samples cultured for *Salmonella* isolation.	- *Salmonella* can persist well in the environment if protected from direct sunlight and can spread via water systems. - *Salmonella* detected from macropodids (kangaroos and wallabies) and toads. - Reptiles are the major carriers of *Salmonella* in wildlife populations. - Transmission of *Salmonella* to humans from pets or animals in captivity.

No.	Authors	Reference Details	Objectives	Methods	Key results
7	Williams S, Patel M, Markey P *et al*.	Journal of Infection, 2015; 71(6): 642-648.	To describe the distribution of *Salmonella* in the household environment.	- Collected environmental samples from case (previous infection in child aged 0-4 yrs 2005-2008) and control houses.	- *Salmonella* isolated in 86/325 (26%) of household samples. - *Salmonella* detected in a pet dog, frog and gecko faeces, soil, vacuum cleaner contents and turtle aquarium sediment and water.
8	Ahmed W, Hodgers L, Sidhu J, Toze *S.*	Applied and Environmental Microbiology, 2012; 78(1): 219-226.	- To determine the prevalence of faecal indictors, zoonotic bacterial and protozoan pathogens in water samples from rainwater tanks and connected household taps. - To determine the prevalence of the above pathogens in faecal samples from possums and wild birds.	- Sampling conducted at one site: an ecovillage in southeast Queensland. - 2 water tank samples and 1 tap sample collected from 24 households. Samples collected within 1 to 4 days after a rain event (>100 mm). - Possum faecal samples obtained from a possum removal service (wildlife carer). - Bird faecal samples obtained from botanical gardens, bird sanctuaries and a veterinary hospital. - Samples were tested either using culture or PCR methods.	- 10% of the population use roof harvested rain water as a major source of drinking water. - Only 1 (4%) water sample was positive for *Salmonella* species. - *Salmonella* was detected in 11% of 38 bird faecal specimens. - *Salmonella* was not detected in the 40 possum faecal samples tested. - Study limited by sample size – only one site used for water survey and relatively small sample of possum and wild bird specimens.

No.	Authors	Reference Details	Objectives	Methods	Key results
9	Sidhu J, Hodgers L, Ahmed W *et al*.	Water Research, 2012; 46(20): 6652-6660.	To survey the presence of enteric bacterial and viral pathogens in stormwater runoff in Brisbane.	- Six study sites (creeks and rivers) included - Samples collected from November 2010 to May 2011. - 2 samples collected from each site during a dry period (no rain within 48hrs prior to sampling) and 2 samples collected after >10 mm precipitation. - Samples tested using PCR.	- *Salmonella* detected at least once from each site, predominately after rainfall. - Risk of faecal contamination of stormwater from aging sewage infrastructure. - Contamination of stormwater runoff potentially caused by human faecal contamination rather than contamination from animals.
10	Dale K, Kirk M, Sinclair M *et al*.	Australia and New Zealand Journal of Public Health, 2010; 34(5): 527-530.	To review national data on waterborne outbreaks of gastrointestinal disease.	- OzFoodNet outbreak register reviewed and information obtained for waterborne outbreaks from 2001 to 2007.	- 54 outbreaks classified as waterborne or suspected waterborne. - 42 (54%) were attributed to recreational water contact. - *Salmonella* species implicated in 5 outbreaks. - 1 recreational water outbreak confirmed as *Salmonella* Litchfield.

No.	Authors	Reference Details	Objectives	Methods	Key results
11	Parsons S, Bull C, Gordon D.	Applied and Environmental Microbiology, 2015; 81(17): 5804-5811.	To study the distribution of 4 subspecies of *S.* enterica in a population of sleepy lizards (shingleback).	- Lizards studied over the spring and study period over 3 years (2001, 2002, 2006). - Individual lizards radiotracked and sampled for *S.* enterica at regular intervals during the study period. - Cloacal swabs used and transported to ANU for testing.	- Among native animals in Australia, *Salmonella* is primarily carried by reptiles. - *Salmonella* survives in dry environmental conditions better than other bacteria, such as *E. coli*. - *S. enterica* subs. *enterica* found in 36% of isolates.
12	Scheelings T, Lightfoot D, Holz P.	Journal of Wildlife Diseases, 2011; 47(1): 1-11.	To determine the prevalence of *Salmonella* in captive and wild reptiles and to determine if environment relates to the carriage of specific serotypes.	- Cloacal or intestinal swabs collected from 504 reptiles (57 species) from January 2007 to June 2008. - Captive reptiles sampled from Healesville Sanctuary and private animal collections. - Wild reptiles sampled as they were admitted to the Australian Wildlife Health Centre for injury or displacement. - Samples cultured for *Salmonella*.	- 139 (27.6%) of all reptiles sampled were positive for *Salmonella*. - Captive reptiles had a higher rate of shedding than wild animals, which could be due to the stress of captivity. - Snakes had a higher prevalence (69.2%) than lizards (21.7%). - Animals that ate whole vertebrate prey had a higher prevalence of *Salmonella* than insectivorous reptiles, suggesting that diet may be a contributing factor.

No.	Authors	Reference Details	Objectives	Methods	Key results
13	Callaway Z, Thomas A, Melrose W *et al*.	Vector-borne and Zoonotic Diseases, 2011; 11(6): 621-625.	To determine the prevalence of the Asian house gecko in north Queensland and to determine whether geckos were a potential source of *Salmonella* Virchow.	- Households in Townsville /Thuringowa area randomly selected using a random number generator. Sample size included 100 house geckos from 50 households. - Captured geckos were euthanized and the lower gut was removed for culture.	- 100 geckos collected from 57 households. Prevalence of *Salmonella* in geckos was 7% (7/100). Household prevalence was 12% (7/57). - Weltevreden was the most common serotype (5/7), with 1 gecko positive for Virchow and 1 positive for subspecies 1 serotype 11.
14	Parsons S, Bull C, Gordon D.	Environmental Microbiology Reports, 2010; 2(5): 657-659.	To determine the prevalence of *S. enterica* in Australian wildlife.	- 2489 wildlife hosts sampled, including fish, frogs, reptiles, birds and mammals. - Sampling regions classified as tropical, temperate, grassland and desert). No further information given on where samples were collected from. - No information on types of samples collected. - Most of the animals sampled were in areas free from human activity.	- *Salmonella* enterica detected in 48/2489 samples. - *Salmonella* not isolated from fish, frogs or birds examined. - *Salmonella* detected in 33/443 (7%) of reptiles sampled. Prevalence was highest in lizards. Limitations: - *Salmonella* selective media were not used for isolation, which may have reduced sensitivity. Therefore, reported prevalence may be lower than other studies.

Synthesis

Studies assessing the prevalence of *Salmonella* in wildlife populations and environmental sources were varied in their objectives, methods, study duration and sample size. Four studies attempted to link human infections with either sampled or known prevalence of *Salmonella* in wildlife animals. Iveson *et al* (2014) described human *Salmonella* infections from 1985–2000 from Western Australia (WA) and the Northern Territory (NT) and *Salmonella* positive wildlife isolates collected from subset wildlife populations in WA and the south-eastern Wallacea islands from periods ranging from 1970 to 2000.[2] Whilst the study highlighted the range of serovars isolated from both humans and wildlife, the broad time and geographic span of the study made the link between human and wildlife infection tenuous.

Staff *et al*, Ashbolt & Kirk and Williams *et al* used case-control methods to identify environmental risk factors among human cases infected with *Salmonella*. Ashbolt & Kirk identified cases as having higher odds of exposure to untreated drinking water, living on or visiting a farm, exposure to native bird environments and exposure to pet faeces.[3] Staff *et al* identified cases as having higher odds of exposure to playgrounds with contaminated sand.[4] Staff *et al* conducted environmental sampling of the playground sandpits as well as native wildlife populations in order to connect human infections with the environmental exposures. Thirty-four environmental isolates were identical to human isolates, with the majority of isolates coming from the native long-nosed bandicoot. Williams *et al* investigated the distribution of *Salmonella* in the household environment between cases and controls in the Northern Territory.[5] *Salmonella* was detected in 26% (86/325) household samples, including a pet dog, frog and gecko faeces, soil, vacuum cleaner contents and turtle aquarium sediment and water.

Four studies explored the evidence of human-to-animal or human-to-environmental transmission of *Salmonella* in Australia. Dolejska *et al* reported a high prevalence of *Salmonella* among silver gulls at the Five Island nesting colony in south east New South Wales.[6] It was identified that an important source of food for the colony was a local garbage depot, where it was suspected that human-to-animal *Salmonella* transmission may be occurring. Iveson *et al* (2009) explored the impact of sewage effluent and food wastes on native wildlife in both Antarctic wildlife and marine and terrestrial fauna off the coast of Western Australia, however specific links between human sites and animal populations were unable to be drawn.[7] The authors theorised that contamination could also be occurring at sea from commercial shipping activities. Iveson *et al* (2014) posited that tourism and human/animal interactions had increased the breadth of *Salmonella* serovars circulating in wildlife populations.[2] However, this study had a number of limitations in relation to sampling sites and timeframes.

Contamination of waterways with *Salmonella* poses a risk of infection to both humans and animals. Sidhu *et al* investigated the presence of enteric bacterial pathogens in stormwater runoff in Brisbane.[8] The authors determined that contamination of stormwater runoff was more likely to be caused by human faecal contamination through aging sewage rather than through contamination by animals. Indeed, recreational water contact was attributed as the source of 42 (54%) outbreaks of gastrointestinal disease in Australia from 2001 to 2007 by Dale *et al*.[9] Whilst untreated drinking water has been identified as a source of *Salmonella* in other studies, Ahmed *et al* only identified *Salmonella* in 1 (4%) sample of roof harvested rainwater in a study conducted in 2012.[10] However, this study had a number of limitations in relation to sample size.

The reported prevalence of *Salmonella* among wildlife populations can vary substantially among studies due to sampling methods, geographic location and time of year.[11] A number of the studies reviewed focused on specific subgroups within wildlife populations, which may detract from their generalisability.[6,12-14] Having said this, the detection of *Salmonella* in a particular wildlife species, even in small numbers, reveals the potential involvement of this species in transmission pathways. Two studies attempted to determine the prevalence of *Salmonella* among a wide range of wildlife species. Thomas *et al* reviewed 233 wildlife samples from 25 different species collected by a veterinary reference laboratory over a 20-year period (1978–1998).[15] *Salmonella* was detected in macropods (kangaroos and wallabies), toads and reptiles. Thomas *et al* highlighted possible human infection through contact with pets and animals in captivity who are more likely to shed the bacteria. Parsons *et al* (2010) conducted a prevalence study with a larger sample size (n=2489) in which they detected low levels of *Salmonella* among wildlife populations.[11] Positive samples were detected in crocodiles, snakes, lizards, carnivorous marsupials and rodents. However, this study did not use *Salmonella* selective media during the culturing of samples and therefore prevalence estimates may be lower than other studies.

Conclusion

Studies researching the prevalence of *Salmonella* in Australian wildlife populations and environmental sources have been largely ad hoc and focused on specific sub groups within the wildlife population. Prevalence estimates have varied according to sampling methods, sample size, geographic location and time of year. However, the studies reviewed have highlighted the breadth of potential animal and environmental reservoirs for *Salmonella* in Australia. Transmission pathways for *Salmonella* are complex and influenced by both host and environmental factors.[12] Furthermore, disease transmission may be bi-directional; occurring both from animals/environments to humans and from humans to animals/environments.[16]

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Appendix 4.3: Conference presentation, Communicable Diseases Control Conference, Melbourne 27 June 2017

Environmental risk factors for Salmonella serovar Wangata in north east NSW

Julie Collins
Master of Philosophy (Applied Epidemiology), Australian National University
OzFoodNet, Hunter New England Population Health

Health
Hunter New England
Local Health District

Background

Salmonella Wangata

- Second most commonly notified serovar in northern NSW
- No common food items identified through interviews
- Isolated in animals through ad hoc testing

The Wangata Project

- One Health initiative
- 3 Local Health Districts in northern NSW
- November 2016 – April 2017

What did we do?

S. Wangata v. *S.* Typhimurium

Environmental exposures

- Property / residence
  - Private water use, home-grown foods, contact with soil
- Direct / indirect animal contact
  - Household pets, livestock, native animals
- Outdoor activities
  - Local parks, national parks, contact with water

What did we find?

	S. Wangata	*S.* Typhimurium
Enrolled in the study	52	55
Males	28 (54%)	31 (56%)
Median age (years)	54 (range 3m–88)	29 (range 2–83)
Local Health District - Hunter New England - Mid North Coast - Northern NSW	7 (13.5%) 12 (23.0%) 33 (63.5%)	33 (60.0%) 8 (14.5%) 14 (25.5%)

	Odds Ratio (95% CI)*	P-value
Bats/flying foxes (indirect contact)	2.63 (1.11–6.20)	0.028
Native frogs (indirect contact)	2.48 (1.00–6.13)	0.049

*Multivariate logistic regression, Stata 14.1

Where to next?

- Possible indirect contact with wildlife exposures (bats/flying foxes and native frogs)
  - However, patient recall of environmental exposures generally poor
- Additional methods
  - Environmental sampling
  - Whole genome sequencing

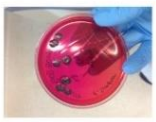

Photo credit: Kelly Simpson

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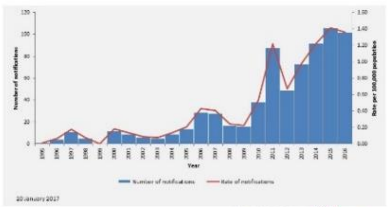
S. Wangata notifications in NSW, 1995 - 2016



Environmental sampling

- Cases' residences
- Sample types:
  - Water
  - Soil
  - Animal faeces
- Additional arm
  - Wildlife carers
  - Faecal specimens / swabs

Appendix 4.4: *Salmonella* Wangata Project Questionnaire (Telephone)

Salmonella Wangata

CASE-CONTROL QUESTIONNAIRE

Participant ID:

☐ Case (*Salmonella* Wangata)	☐ Control (*Salmonella* Typhimurium)

AGE GROUP
☐ 0-4 years ☐ 5-14 years ☐ 15-64 years ☐ 65 years and over

PRE INTERVIEW INFORMATION		
Notification ID (NCIMS No) :		
First Name:		Last Name:
DOB:	Age:	Sex: ☐ Female ☐ Male ☐ Other
Address:		Telephone 1:
		Telephone 2:

ATTEMPTS TO CONTACT				
	Date	**Time**	**Interviewer**	**Outcome**
1	____/____/____			
2	____/____/____			
3	____/____/____			
4	____/____/____			
5	____/____/____			
6	____/____/____			

INTRODUCTION

"Hello, my name is _____ and I work for the local Department of Health.

For adults: **May I please speak with _____** <name of case>?

For children: **May I please speak with the parent or guardian of _____** <name of case>?

INTERVIEWER: When the case/control comes to the phone, repeat the introduction then proceed with the explanatory statement.

If the case/control is unavailable, then arrange an alternative time for the interview.

"I believe you have [your child has] been unwell recently and had a stool sample collected, is that correct?"

Did the doctor provide you with the results of your stool sample? (If no, advise that the stool was positive for *Salmonella*)

***Salmonella* is a notifiable infectious disease, which means that doctors and laboratories are required to notify the Health Department. We are currently conducting an investigation into an increase of cases with *Salmonella*. We would like to ask you some questions about your [your child's] illness using a survey.**

The topics covered by the survey include clinical information about your illness, travel information, foods eaten, outdoor or environmental exposures and possible contact with animals that you [your child] may have had before becoming unwell.

The questions should take about 20 minutes. Your participation is voluntary. Confidentiality will be protected as far as the law allows. Can you assist us by participating in this investigation?"

☐ Yes

☐ No - reason for not participating: ☐ No time ☐ Not interested ☐ Other:

For children 15-17 years :

"Do you give your consent for me to speak directly with _____<name of case>?"

INTERVIEWER: Please note that for cases/controls under the age of 15 years, (and those 15-17 if the parent is being interviewed) questions relate to the case/control, not the person being interviewed unless specified in the body of the questionnaire.

"You may withdraw from the survey at any time. If you any concerns about participating in this investigation you can discuss them with me, or if you have a complaint about the manner in which the investigation is conducted and would like to speak to an independent person, you are welcome to contact Dr Nicole Gerrand, Manager of Research Ethics and Governance at Hunter New England Local Health District on (02) 4921 4950."

SECTION 1: DEMOGRAPHIC DETAILS

"To start, I would just like to confirm some of your details…"

Interviewer to complete prior to interview:	DOB:	DOB correct? ☐ Yes ☐ No

1. **Were you [your child] born in Australia?** ☐ Yes ☐ No

2. **Do you [does your child] identify as being of Aboriginal or Torres Strait Islander origin?** *(tick all that apply)*

   ☐ No - neither ☐ Yes - Aboriginal ☐ Yes – Torres Strait Islander ☐ Yes – both ☐ Prefer not to say

"Because I will be asking about specific dates around the time of your illness, it may be helpful for you to have a calendar or diary in front of you. Do you need a few minutes to get these?"

SECTION 2: CLINICAL INFORMATION

Interviewer to complete prior to interview: Date of specimen collection: ____/____/____

"I am now going to ask some questions about your [your child's] illness."

3. **What date did your [your child's] diarrhoea begin?** ____/____/____

   (If person is unsure, prompt with the date of stool specimen collection above)

   ☐ Unsure / no clear onset date *(END INTERVIEW – see below)*

   ☐ No diarrhoea *(END INTERVIEW – see below)*

4. **In the 2 weeks before your [your child's] illness began, did anyone else in your household have diarrhoea?**

   ☐ Yes *(END INTERVIEW – see below)*

   ☐ No

   ☐ Don't know/unsure

INTERVIEWER:

If case cannot recall diarrhoea onset date or did not experience diarrhoea – END INTERVIEW with:

"Since you are unable to recall the date that your [your child's] diarrhoea began / you [your child] did not experience any diarrhoea, we will not be able to include you in your investigation.

CONTINUED ON NEXT PAGE

If there was someone in the case's household with diarrhoea in the 2 weeks prior – END INTERVIEW with:

"Since there was someone else in your household who was unwell with diarrhoea before you, we will not be able to include you in our investigation. It is possible that you may have caught the *Salmonella* infection from them.

Are there any questions you would like to ask me?

Would you like me to send you some information about *Salmonella*?

Thank you very much for your time and cooperation."

5. Did you [your child] experience any of the following symptoms associated with the illness?

Symptom	Yes	No	Don't Know/Unsure
Diarrhoea	☐	☐	☐
Abdominal pain (stomach cramps)	☐	☐	☐
Blood in your stool	☐	☐	☐
Nausea	☐	☐	☐
Vomiting	☐	☐	☐
Fever	☐	☐	☐
Headache	☐	☐	☐
Lethargy (tiredness)	☐	☐	☐
Muscle / body aches	☐	☐	☐
Other symptoms	☐	☐	☐
If other symptoms, please specify:			

6. Were you [was your child] admitted to hospital for this illness?

☐ Yes

☐ No

☐ Don't know/unsure

7. If yes, for how many nights were you [was your child] hospitalised?

nights

(Note: If admitted for less than one night, put <1 night)

8. *(Do not ask if case is a child less than 15 years)* ☐ Not applicable

When your symptoms began, were you employed as a health care worker, child-care worker or food preparer/food handler?

☐ Yes

☐ No

☐ Don't know/unsure

INTERVIEWER: If 'yes' to the question above, you will need to ensure this is followed up with the relevant public health action.

SECTION 3: TRAVEL INFORMATION

9. In the 7 days before your [your child's] diarrhoea began, did you [your child] travel more than 100kms from your home? *(This includes overseas, interstate and travel within NSW)*

☐ Yes *(END INTERVIEW – see below)*

☐ No

☐ Don't know/unsure. *If unsure of distance, location of travel*:

If the case/control travelled during the exposure period (7 days prior to diarrhoea onset)
END THE INTERVIEW with: **"Since you were travelling during the exposure period, we will not be able to include you in our investigation. Thank you for your assistance today."**

FOOD EXPOSURES

"I am now going to ask some questions about your [your child's] food exposures. For these questions, we are only interested in food consumed in the 7 days prior to the onset of your [your child's] diarrhoea."

For you [your child], your first day of illness was: ____/____/____ 7 days before this was: ____/____/____

10. Did you [your child] eat from any cafes, restaurants or fast food outlets?

☐ Yes *(complete table below)*

☐ No

☐ Don't know/unsure

Name	Location	Ate food inside/outside	Date and time of consumption	Foods consumed
		☐ Inside ☐ Outside	____/____/____ ☐ AM ☐ PM	
		☐ Inside ☐ Outside	____/____/____ ☐ AM ☐ PM	

11. Did you [your child] eat food purchased from a farmers market or local market?

(Interviewer: prompt for fresh produce: fruit and vegetables, nuts, meats, eggs)

☐ Yes *(complete table below)*

☐ No

☐ Don't know/unsure

Market name	Market location	Date and time of consumption	Foods consumed
		____/____/____ ☐ AM ☐ PM	
		____/____/____ ☐ AM ☐ PM	

SECTION 4: PROPERTY EXPOSURES

"I am now going to ask some questions about the property that you live on."

12. What is the size of the property that you live on?

☐ 1/4 acre or less / standard house block

☐ Greater than 1/4 acre to 5 acres / 0.1 – 2 hectares

☐ Greater than 5 acres / Greater than 2 hectares

13. Do you use a private water supply on your property? (Eg. Rainwater tank, bore water)

☐ Yes

☐ No

☐ Don't know/unsure

If yes, do you use the water for: *(tick for yes)*

☐ Drinking & food preparation

☐ Showering/bathing or oral hygiene (brushing teeth)

☐ Watering fruit, vegetables or herbs

☐ Other. *Please specify*:

14. Do you grow any fruit on your property? (Eg. orange, apple, mango)

☐ Yes. *Please specify*:

☐ No

☐ Don't know/unsure

15. Do you grow any nuts on your property? (Eg. macadamia, pecan)

☐ Yes. *Please specify*:

☐ No

☐ Don't know/unsure

16. Have you seen any bats/flying foxes on your property? (this includes bats flying over your property)

☐ Yes ☐ No ☐ Don't know/unsure

If yes, when was the last time you saw bats/flying foxes on your property?

☐ Less than 1 week before the date that diarrhoea began

☐ 1 week to 1 month before the date that diarrhoea began

☐ More than a month before the date that diarrhoea began

☐ Don't know / unsure

17. Do you grow any vegetables or herbs on your property?

☐ Yes. *Please specify*:

☐ No

☐ Don't know/unsure

18. In the 7 days prior to the onset of your [your child's] diarrhoea, did you [your child] eat any food that was grown at home?

☐ Yes. *Please specify*:

☐ No

☐ Don't know/unsure

19. In the 7 days prior to the onset of your [your child's] diarrhoea, did you [your child] have had any contact with soil or grass? *(e.g. gardening, mowing or kids playing)*

☐ Yes. *Please specify*:

☐ No

☐ Don't know/unsure

SECTION 5: HOUSEHOLD PET EXPOSURES

"I am now going to ask about any direct or indirect contact you [your child] may have had with household pets or their faeces.

Direct contact includes patting or touching the pet, or having contact with the pet's faeces.

Indirect contact includes feeding or being in the same environment as the pet *(i.e. room, house, property)***."**

Direct	Indirect
Patting or touching	Feeding *(if no direct contact)*
Contact with faeces *(dogs – cleaning up faeces at home and during walks, kitty litter, cleaning bird cage or animal tank)*	Being in the same environment

20. In the 7 days prior to when your [your child's] diarrhoea began, did you [your child] have any direct or indirect contact with a:

Pet	**Type of contact**
Dog/Puppy	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Cat/Kitten	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Bird	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Chicken	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Fish	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Pet turtle	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Pet snake	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Pet lizard *Please specify*:	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know
Other *Please specify:*	☐ No contact ☐ Direct contact ☐ Indirect contact ☐ Don't know

21. *If yes to direct or indirect contact with a dog/puppy in Q20 (otherwise go to Q24)*

Do you own the dog/puppy that you [your child] had contact with?

☐ Yes

☐ No (go to Q24)

22. In the 7 days prior to your [your child's] illness, was the dog/puppy taken for a walk outside of your property?

☐ Yes. *Specify name and location of any parks:*

☐ No

☐ Don't know / unsure

23. In the 7 days prior to your [your child's] illness, did the dog/puppy have contact with a natural water source? (Eg. creek, river, lake or beach)

☐ Yes. *Specify name and location:*

☐ No

☐ Don't know / unsure

24. *If yes to direct or indirect contact with a cat/kitten in Q20 (otherwise go to Q27)*

Do you own the cat/kitten that you [your child] had contact with?

☐ Yes

☐ No (go to Q27)

25. Is your cat/kitten normally an indoor or an outdoor cat/kitten?

☐ Indoor cat ☐ Outdoor cat ☐ Both

26. Is the cat/kitten known to eat [or was there any evidence that the cat/kitten ate] native animals?

☐ Yes ☐ No ☐ Don't know/unsure

SECTION 6: OTHER ANIMAL EXPOSURES

"I am now going to ask about any direct or indirect contact you [your child] may have had with other animals.

This includes animals that were part of a petting zoo, commercial zoo or agricultural show, as well as animals on your property or surrounding areas.

Please do not include contact with any animals that you previously identified as being a "pet." *(Q19)*

Direct contact includes patting or touching the animal or having contact with the animal's faeces.

Indirect contact includes feeding or being in the same environment as the animal."

Direct	Indirect
Patting or touching	Feeding *(if no direct contact)*
Contact with faeces *(this includes getting it on your shoes)*	Being in the same environment *(i.e. property)*

27 In the 7 days prior to when your [your child's] diarrhoea began, did you [your child] have any direct or indirect contact with a:

Animal	**Type of contact**			
Cow / calf	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Sheep / lamb	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Horse / foal	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Goat / kid	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Alpaca	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Pig	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Chicken	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know

Kangaroo/ wallaby	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Quoll/native cat	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Possum	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Bandicoot	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Ibis	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Seagull	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Duck	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Bird (other) *Specify:*	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Bat/flying fox	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Native frog	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Native snake	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Native lizard *Please specify*:	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know
Other. *Please specify*:	☐ No contact	☐ Direct contact	☐ Indirect contact	☐ Don't know

28 *If yes to direct or indirect contact with any of the animals listed above (otherwise go to Q29)*

Did you have any contact with animals at the following locations:

Petting zoo ☐ Yes ☐ No

Commercial zoo ☐ Yes ☐ No

Agricultural show ☐ Yes ☐ No

If yes, please specify the name and location of the zoo/show and the animals that you [your child] had contact with:

SECTION 7: OTHER OUTDOOR EXPOSURES

29. In the 7 days prior to when your [your child's] diarrhoea began, did you [your child] go to a local park or playground.

☐ Yes. *Specify name and location*:

If yes, did you [your child]: *(tick for yes)*

☐ Play in or have contact with sand/mulch/dirt

☐ Drink from a bubbler or tap

☐ Have contact with water from a water feature, such as a fountain or pond

☐ No

☐ Don't know/unsure

30. In the 7 days prior to when your [your child's] diarrhoea began, did you [your child] go to a national park or reserve?

☐ Yes. *Specify name and location*:

☐ No

☐ Don't know/unsure

31. **In the 7 days prior to when your [your child's] diarrhoea began, did you [your child] have contact with a natural water source, such as a creek, river, lake or beach?**
(e.g. swimming, fishing or walking through water)

☐ Yes. *Specify name and location*:

☐ No

☐ Don't know/unsure

32. **In the 7 days prior to when your [your child's] diarrhoea began, did you [your child] swim in a pool?**

☐ Yes.

If yes, where was the pool:

☐ At own residence

☐ Other. *Please specify*:

☐ No

☐ Don't know/unsure

CONCLUSION

"That is the end of the information that I need to collect from you today. Thank you for your time.

The information you provide in this questionnaire is for the purpose of trying to prevent further cases of illness in the community.

The data collected is kept confidential and identifying information will not be disclosed for any other purpose without your consent.

If we have further questions or need to clarify information, could we contact you again? ☐Y ☐N

CASES ONLY

As a part of our current investigation, we are asking people if they would consent to our public health staff taking some environmental samples from your property.

The reason for this is that we are trying to determine if you may have been exposed to *Salmonella* in your environment. The types of samples that we would like to collect are soil, water and animal faecal specimens if they are present on your property.

Would you assist us in the investigation by allowing us to collect environmental samples from your property? ☐Y ☐N

If yes: **Thank you. I will have one of our public health staff contact you again to arrange an appropriate time for collection.**

Can I confirm the best telephone number to contact you:

To assist with scheduling, could you tell me the days / times of the week that would be best for our public health staff to attend your property?

☐ Monday	☐ Tuesday	☐ Wednesday	☐ Thursday	☐ Friday
☐ AM ☐ PM	☐ AM ☐ PM	☐ AM ☐ PM	☐ AM ☐ PM	☐ AM ☐ PM

INTERVIEW COMPLETED BY
Name of Interviewer: Date of interview: ____/____/____ Length of interview: minutes How well did the case recall the information requested? ☐ very well ☐ well ☐ not well ☐ not at all
GENERAL NOTES

Appendix 4.5: Multivariable model building steps in Stata – STm control group

Model	Variables	*p* value*	Outcome
	Full model		
A	casecontrol age_years i.sex i.rural grow_fruit i.horse i.ibis i.seagull i.bat i.native_frog i.native_lizard	reference	
B	casecontrol age_years i.sex i.rural grow_fruit i.horse i.ibis i.seagull i.bat i.native_frog	0.9539	i.native_lizard removed
C	casecontrol age_years i.sex i.rural grow_fruit i.horse i.ibis i.bat i.native_frog	0.6236	i.seagull removed
D	casecontrol age_years i.sex i.rural i.horse i.ibis i.bat i.native_frog	0.5279	grow_fruit removed
E	casecontrol age_years i.sex i.rural i.horse i.bat i.native_frog	0.4772	i.ibis removed
F	casecontrol age_years i.sex i.rural i.bat i.native_frog	0.1319	i.horse removed
	Main effects model		
F	casecontrol age_years i.sex i.rural i.bat i.native_frog		
	Assessing interaction terms		
G	casecontrol age_years i.sex i.rural i.bat i.native_frog i.sex#i.bat i.sex#i.native_frog	0.4867	sex and i.bat/i.native_frog interaction term removed
H	casecontrol age_years i.sex i.rural i.bat i.native_frog i.rural#i.bat i.rural#i.native_frog	0.7949	i.rural and i.bat/i.native_frog interaction term removed
	Testing model fit		
	Hosmer-Lemeshow goodness of fit test	0.9500†	
	Area under the ROC curve	0.7198‡	

** Likelihood ratio test*

† Hosmer-Lemeshow X^2

‡ Calculation of area under the ROC curve shows acceptable discrimination

Appendix 4.6: Multivariable model building steps in Stata – Neighbourhood control group

Model	Variables	*p* value*	Outcome
	Full model		
A	casecontrol i.age_group i.rural local_park_playground pool i.dog i.cat i.kangaroo i.possum i.bandicoot i.ibis i.seagull i.duck i.native_bird i.bat i.native_frog i.native_snake i.native_lizard	reference	
B	casecontrol i.age_group i.rural local_park_playground pool i.dog i.cat i.kangaroo i.possum i.bandicoot i.ibis i.seagull i.duck i.native_bird i.bat i.native_frog i.native_snake i.native_lizard	0.5074	i.horse removed
C	logistic casecontrol i.age_group i.rural local_park_playground pool i.dog i.kangaroo i.possum i.bandicoot i.ibis i.seagull i.duck i.native_bird i.bat i.native_frog i.native_snake i.native_lizard	0.7477	i.cat removed
D	casecontrol i.age_group i.rural local_park_playground pool i.dog i.kangaroo i.possum i.bandicoot i.seagull i.duck i.native_bird i.bat i.native_frog i.native_snake i.native_lizard	0.9898	i.ibis removed
E	casecontrol i.age_group i.rural local_park_playground pool i.dog i.kangaroo i.possum i.seagull i.duck i.native_bird i.bat i.native_frog i.native_snake i.native_lizard	0.5986	i.bandicoot removed
F	casecontrol i.age_group i.rural local_park_playground pool i.kangaroo i.possum i.seagull i.duck i.native_bird i.bat i.native_frog i.native_snake i.native_lizard	0.4519	i.dog removed
G	casecontrol i.age_group i.rural local_park_playground pool i.kangaroo i.possum i.seagull i.duck i.native_bird i.bat i.native_snake i.native_lizard	0.5948	i.native_frog removed
H	casecontrol i.age_group i.rural local_park_playground pool i.kangaroo i.possum i.seagull i.duck i.native_bird i.bat i.native_snake	0.4297	i.native_lizard removed
I	casecontrol i.age_group i.rural local_park_playground pool i.kangaroo i.possum i.seagull i.native_bird i.bat i.native_snake	0.4326	i.duck removed
J	casecontrol i.age_group i.rural local_park_playground pool i.kangaroo i.possum i.native_bird i.bat i.native_snake	0.4381	i.seagull removed
K	casecontrol i.age_group i.rural local_park_playground pool i.kangaroo i.possum i.bat i.native_snake	0.0005	i.native_bird retained

Model	Variables	*p* value*	Outcome
L	casecontrol i.age_group i.rural local_park_playground pool i.kangaroo i.possum i.native_bird i.bat	0.2958	i.native_snake removed
M	casecontrol i.age_group i.rural pool i.kangaroo i.possum i.native_bird i.bat	0.1696	local_park_playground removed
N	casecontrol i.age_group i.rural pool i.possum i.native_bird i.bat	0.1813	i.kangaroo removed
O	casecontrol i.age_group i.rural i.possum i.native_bird i.bat	0.4432	pool removed
P	casecontrol i.age_group i.rural i.native_bird i.bat	0.1695	i.possum removed
	Main effects model		
Q	casecontrol i.age_group i.rural i.native_bird i.bat		
	Assessing interaction terms		
R	casecontrol i.age_group i.rural i.native_bird i.bat i.age_group#i.native_bird i.age_group#i.bat	0.0112	i.bat interaction removed
S	casecontrol i.rural i.age_group##i.native_bird i.bat	0.0413	i.age_group and i.native_bird interaction term *p* values assessed. Values not significant in model. Interaction term removed
T	casecontrol i.rural i.age_group##i.bat i.native_bird	0.4423	i.age_group and i.bat interaction term removed
U	casecontrol i.age_group i.rural i.native_bird i.bat i.rural#i.native_bird i.rural#i.bat	0.0766	i.rural and i.bat / i.native_bird interaction terms removed
	Testing model fit		
	Hosmer-Lemeshow goodness of fit test	0.2324†	
	Area under the ROC curve	0.8863‡	

** Likelihood ratio test*

† Hosmer-Lemeshow X^2

‡ Calculation of area under the ROC curve shows excellent discrimination

Appendix 4.7: *Salmonella* Wangata Project - Piloting of environmental sampling protocol

OzFoodNet staff and Environmental Health Officers pilot the environmental sampling protocol with Kelly Simpson in Hunter New England Local Health District.

Environmental Health Officers in Mid North Coast Local Health District pilot the environmental sampling protocol with Kelly Simpson and Julie Collins.

Northern NSW Environmental Health Officer in action during the piloting of the environmental sampling protocol.

Chapter 5 - Evaluation of a surveillance system

Early Warning Alert and Response System

(EWARS in a Box) post Tropical Cyclone Winston, Fiji, 2016

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Abbreviations

CDC	Centers for Disease Control and Prevention
EWARN	Early Warning Alert and Response Network
EWARS	Early Warning Alert and Response System
FCCDC	Fiji Centre for Communicable Disease Control
GOARN	Global Outbreak Alert and Response Network
MoHMS	Ministry of Health and Medical Services
WHO	World Health Organization
WHO DPS	WHO Division of Pacific Technical Support (Suva)
WHO HQ	WHO Headquarters (Geneva)

5.1 Prologue

5.1.1 Introduction

This evaluation was undertaken as a part of a World Health Organization (WHO) Global Outbreak Alert and Response Network (GOARN) deployment to Fiji in May 2016. WHO implemented a sentinel, syndromic surveillance system to monitor potential outbreaks of communicable diseases following Tropical Cyclone Winston, which struck Fiji in February 2016. This was the first time that the newly developed, post-disaster EWARS in a Box surveillance system had been implemented in the Pacific region.[1] This evaluation of the system's first three months of operation was conducted to provide information to the Fiji Ministry of Health and Medical Services (MoHMS) on the performance of the system and its possible value as an ongoing, routine surveillance system. In addition, the evaluation provided recommendations to WHO on the implementation of the EWARS in a Box system in post-disaster settings.

The evaluation was jointly conducted by myself and fellow MAE Scholar, Meru Sheel. Meru and I were deployed to Fiji for 6 weeks and 4 weeks respectively in April–May 2016, and were asked to complete the evaluation within the duration of our deployment. We primarily followed the evaluation framework outlined in the Centers for Disease Control and Prevention (CDC)'s Updated Guidelines for Evaluating Public Health Surveillance Systems.[2,3] In order to maximise efficiency under these short timeframes, Meru and I allocated the evaluation of each of the surveillance system attributes between us, with some overlap for certain attributes.

This chapter outlines my role in the joint evaluation and provides a summary of the evaluation methods I used. The combined evaluation report that Meru and I prepared for the Fiji Centre for Communicable Disease Control (FCCDC), the Fiji MoHMS and WHO is provided in **Appendix 5.1**. The surveys used to assess user experiences are also provided in **Appendix 5.2** and **Appendix 5.3.**

5.1.2 My role

My role focused on developing and administering user experience surveys for those contributing data to the system from sentinel sites (focal points) and those verifying the data reported (surveillance officers). The user experience surveys primarily assessed the system attributes of usefulness, flexibility, acceptability and simplicity. Questions were also asked to assess user knowledge of the system objectives, to ascertain the process flow of the system, and to explore contextual factors around timeliness, stability and data validity.

In addition, I led the assessment of data validity through a retrospective review of registers from selected sentinel sites. I was involved in the collection of data from sentinel sites in the Northern Division and collated and analysed the data from all sites.

I co-authored the evaluation report provided to the FCCDC, the Fiji MoHMS and WHO (**Appendix 5.1**).

5.1.3 Lessons learnt

This experience taught me valuable lessons in a number of different areas:

- I learnt a lot about syndromic surveillance and its usefulness in identifying possible outbreaks, particularly in settings where laboratory capacity is limited and laboratory-confirmed diagnoses can be difficult to obtain;

- I learnt about the benefits and challenges of mobile phone based surveillance systems, particularly in countries that have varying levels of mobile coverage;

- I learnt about the challenges of conducting an evaluation or program assessment in a multi-agency environment and the need to engage key stakeholders from multiple levels; and

- I learnt that engaging health workers and those reporting to the system is critical when implementing a new system, particularly when health workers are required to report to multiple systems due to vertical health programs and have limited time to engage in surveillance. In addition, engaging health workers is imperative in understanding the 'why' of a system's performance. Whilst a quantitative assessment of a surveillance system can tell you how a system is performing, it cannot necessarily tell you why that is the case and what can be done to improve performance. In order to make appropriate recommendations to improve system performance, it is critical to engage with those who report to the system.

5.1.4 Public health impact

The surveillance system evaluation findings were presented to WHO Division of Pacific Technical Support (WHO DPS), FCCDC and divisional public health teams. An evaluation report was then prepared for WHO, FCCDC and the Fiji MoHMS.

We made a number of practical recommendations to improve the EWARS system for use in future post-disaster settings. These recommendations were shared with WHO

DPS and WHO Headquarters (WHO HQ) through the evaluation report and will be considered in the future implementation of EWARS in a Box.

We also made a number of recommendations for the possible incorporation of the EWARS system into Fiji's routine public health surveillance. These recommendations were shared with the FCCDC, the Fiji MoHMS and the district medical officers through the evaluation report. The EWARS system has been maintained in Fiji's public health surveillance and continues to assist in the detection of possible outbreaks.

5.1.5 Acknowledgements

I would like to thank my co-evaluator, Meru Sheel, for her ongoing dedication, support and humour during this intensive evaluation process. I would like thank the Fiji Centre for Communicable Disease Control (FCCDC) and WHO for their incredible support and assistance during the evaluation process. In addition, the support and assistance of the EWARS surveillance officers and focal points was invaluable. I would also particularly like to thank my supervisors, Katrina Roper and James Flint, who gave wonderful support and guidance in the field during this deployment. I would also like to thank my previous academic supervisors, Buddhima Lokuge and Stephanie Davis, for their support and guidance during this period. I would like to acknowledge Hunter New England Population Health and the Australian National University for supporting me to undertake this deployment.

5.1.6 Master of Philosophy (Applied Epidemiology) core activity requirements

This chapter meets the following core activity requirement:

- Evaluation of a public health surveillance system

5.2 Surveillance evaluation methods

5.2.1 User experience surveys

Two self-administered user experience surveys were conducted as a part of the evaluation: one to focal points and one to surveillance officers (**Appendix 5.2, Appendix 5.3**). Whilst a number of the same questions were asked in both surveys, it was decided to administer separate surveys to enable additional role-specific questions to be asked of each group.

The user experience surveys were developed and administered online using SurveyMonkey®. An online survey was considered the most appropriate administration method as it could be rapidly deployed, respondents could complete the survey at a time that was convenient for them and data could be quickly collated and analysed. Whilst telephone interviews provide benefits by allowing interviewers to clarify information, it was felt that a written questionnaire would be easier for respondents to interpret in this situation; whilst English is widely spoken in Fiji, different accents may have posed barriers to interpretation.

The surveys used a structured format, with closed-ended, multiple choice questions. In addition, open-ended questions were included in certain instances to allow respondents to express their opinions and to add additional detail (**Appendix 5.2, Appendix 5.3**). The survey questions were developed following discussions about the system with FCCDC staff and surveillance officers. The surveys were reviewed by FCCDC staff and WHO consultants prior to deployment. A potential source of bias in the survey data collected is that surveillance officers were aware of the subjects that would be asked prior to participating in the survey. Whilst this may have introduced an element of recall bias, it was considered necessary to consult the surveillance officers to ensure the content of the survey was appropriate for the focal points.

The surveys were deployed via email link to the 34 focal points and 5 surveillance officers involved in the EWARS system. Responses were collected over a two-week period. Response frequencies and proportions were analysed using Microsoft Excel 2010 (Microsoft Corporation, USA). Open ended responses were analysed thematically using Nvivo 11 (QSR International Pty Ltd).

5.2.2 Data validity

Data validity was assessed by comparing the number of cases reported to the EWARS system for two epidemiological weeks to the number of cases detected in the clinic registers for the same weeks. Teams consisting of a WHO consultant epidemiologist and a FCCDC surveillance officer visited 11 EWARS sentinel sites in the Central, Western and Northern Divisions (The Eastern Division was not included due to issues of accessibility). The visits were conducted over two days and sites were selected based on convenience.

The teams conducted a retrospective review of the clinic registers in each site. Using the standard EWARS weekly tally sheet, teams counted the number of cases in the registers meeting the 9 syndrome case definitions for epidemiological weeks 13 and 17. The tally sheets from the retrospective review at each site were then compared to the data that had been submitted to the EWARS system for the respective weeks.

5.3 References

1. Baker R. Using Mobile Technology for Post-disaster Enhanced Surveillance in Fiji. 19 March 2016; Available from: http://www.wpro.who.int/southpacific/mediacentre/releases/2016/mobiletech_surveillance/en/

2. German RR, Lee LM, Horan JM, Milstein RL, Pertowski CA, Waller MN. Updated Guidelines for Evaluating Public Health Surveillance Systems: Recommendations from the Guidelines Working Group. Morbidity and Mortality Weekly Report: Recommendations and Reports 2001;50(RR-13):i-35.

3. Buehler JW, Hopkins RS, Overhage JM, Sosin DM, Tong V, Group CDCW. Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks: Recommendations from the CDC Working Group. Morbidity and Mortality Weekly Report: Recommendations and Reports 2004;53(RR-5):1-13.

Appendix 5.1: EWARS in a Box Evaluation Report

(This appendix has been removed for confidentiality purposes)

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Appendix 5.2: EWARS Evaluation – User Experience Survey 1

Early Warning Alert and Response System (EWARS) Fiji

Participants: Focal Points at each sentinel site

Preamble

The Fiji Centre for Communicable Disease Control, Ministry of Health and Medical Services are evaluating the Early Warning Alert and Response System (EWARS) that was implemented after Tropical Cyclone Winston.

As a part of the evaluation, we are asking you to provide feedback about the system using this survey. Your response is critical to improving disease surveillance in Fiji.

The survey will take approximately 15 minutes. There are no right or wrong answers and we encourage you to provide as much information as you can.

All information provided by you will be kept confidential.

Thank you for your participation.

Demographic Information	**Question Type**	**Attribute**
1. Division a. Central b. Eastern c. Northern d. Western	Dropdown	
2. Health Facility a. 34 site names	Dropdown	
3. Position at Health Facility a. Medical Officer b. Nurse Practitioner c. Sister d. Nurse e. Clinical records (administration) f. Other	Dropdown	
EWARS Purpose and Impact	**Question Type**	**Attribute**
1. What do you think is the purpose of the Early Warning Alert and Response System (EWARS)?	Comment box	Aim and objective
2. Do you think EWARS has had any impact on public health in Fiji? a. Yes, please specify: b. No c. Unsure	Multiple choice – single answer Comment box	Public health importance

EWARS System	Question Type	Attribute
3. In your opinion, how easy is it to use EWARS on the mobile phone? a. Very easy b. Somewhat easy c. Not very easy d. Not at all easy (very difficult)	Multiple choice – single answer	Acceptability
Follow up question for responses c or d: Which aspect of EWARS do you find most difficult?	Comment box	
4. Have you ever had difficulty accessing the EWARS on the mobile phone (application not working)? a. Yes b. No c. Not sure	Multiple choice – single answer	Stability
5. If yes, how often has this occurred? a. Very often *(most weeks)* b. Somewhat often *(more than once a month)* c. Not very often *(less than once a month)* d. Not at all often *(twice or less)*	Multiple choice – single answer	Stability
EWARS Case Definitions	**Question Type**	**Attribute**
4. Are you aware of the EWARS case definitions? a. Yes b. No c. Unsure	Multiple choice – single answer	Data validity
5. How easy is it to classify cases into the syndrome categories? a. Very easy b. Somewhat easy c. Not very easy d. Not at all easy *(very difficult)*	Multiple choice – single answer	Data validity
6. Please specify any challenges in understanding or applying the case definitions	Comment box	Data validity

7. At your health facility, what is the process used to record patients who meet the case definitions? a. Medical officers record cases directly on the EWARS tally sheet at the time a patient is seen b. Medical officers record cases on an EWARS line list c. Weekly review of clinic register or logbook by Medical Officer or Nurse d. Not known e. Other, please specify:	Multiple choice – single answer	Data validity
EWARS Sending Reports	**Question Type**	**Attribute**
8. How do you send/transmit the EWARS weekly reports? *(please tick all that apply)* a. EWARS mobile phone application b. EWARS website (using computer) c. Email d. Telephone Call e. SMS f. Other, please specify:	Multiple choice – multiple answer	Process flow
9. What are your preferred reporting methods? Please rank from most preferred to least preferred (1 - 5). Tick N/A if you have not used this method a. EWARS mobile phone application b. EWARS website (using computer) c. Email d. Telephone Call e. SMS	Drop down - rank	Process flow
10. Have there been situations where you could not submit the EWARS weekly report on time (before Monday 6pm)? a. Yes b. No c. Unsure	Multiple choice – single answer	Timeliness
11. What are the most common challenges for timely reporting? (Tick all that apply)? a. Tally sheet not received on time from other staff b. No access to internet (no credit) c. No access to internet (no signal) d. No access to phone e. Not enough time, workload too busy f. Unsure g. Other, please specify:	Multiple choice – multiple answer	Timeliness

Unusual Events	Question Type	Attribute
12. What would you do if you identified an unusual public health event? *Eg: unexpected deaths, cluster of illness, animal die off, environmental hazard etc.*	Comment box	Process flow / EBS
EWARS Syndromes	**Question Type**	**Attribute**
13. Do you think the number of syndromes reported to EWARS is appropriate? a. Yes b. No – too many syndromes c. No – too few syndromes d. Unsure	Multiple choice – single answer	Simplicity
14. How easy was it to amend the reporting process when an additional syndrome (Zika-like illness) was added to EWARS? a. Very easy b. Somewhat easy c. Not very easy d. Not at all easy *(very difficult)*	Multiple choice – single answer	Flexibility
Follow up question: What are the main reasons why it was difficult to amend the reporting process	Comment box	
EWARS Usefulness	**Question Type**	**Attribute**
15. How well do you think EWARS is able to signal an early warning for potential disease outbreaks? a. Very well b. Somewhat well c. Not very well d. Not at all well	Multiple choice – single answer	Usefulness
16. Have you received any feedback when an EWARS alert has been generated for your health facility? a. Yes b. No c. Unsure d. (Not applicable)	Multiple choice – single answer	Usefulness
17. Do you receive the EWARS Weekly Bulletin? a. Yes b. No c. Unsure	Multiple choice – single answer	Usefulness

18. How useful is the information in the EWARS Weekly Bulletin for your Health Facility? a. Very useful b. Somewhat useful c. Not very useful d. Not at all useful	Multiple choice – single answer	Usefulness
19. How have you used the information in the EWARS Weekly Bulletin?	Comment box	Usefulness
20. How could the EWARS Weekly Bulletin be improved so that it is more useful for your Health Facility	Comment box	Usefulness
21. Do you ever distribute the information in the EWARS Weekly Bulletin to other people or organisation a. Yes b. No c. Unsure	Multiple choice – single answer	Usefulness
If yes: Who do you distribute the information in the bulletin to?	Comment box	Usefulness
EWARS Training and Support	**Question Type**	**Attribute**
22. How satisfied do you feel with the training that you received when EWARS was implemented?? a. Very satisfied b. Somewhat satisfied c. Not very satisfied d. Not at all satisfied	Multiple choice – single answer	Acceptability
23. How supported do you feel to be able to carry out your EWARS responsibilities? a. Very supported b. Somewhat supported c. Not very supported d. Not at all supported	Multiple choice – single answer	Acceptability
EWARS Overall	**Question Type**	**Attribute**
24. Overall, how satisfied are you with EWARS? a. Very satisfied b. Somewhat satisfied c. Not very satisfied d. Not at all satisfied	Multiple choice – single answer	Acceptability
25. Any further comments?	Comment box	

Appendix 5.3: EWARS Evaluation – User Experience Survey 2

Early Warning Alert and Response System (EWARS) Fiji

Participants: Surveillance Officers

Preamble

The Fiji Centre for Communicable Disease Control, Ministry of Health and Medical Services are evaluating the Early Warning Alert and Response System (EWARS) that was implemented after Tropical Cyclone Winston.

As a part of the evaluation, we are asking you to provide feedback about the system using this survey. Your response is critical to improving disease surveillance in Fiji.

The survey will take approximately 15 minutes. There are no right or wrong answers and we encourage you to provide as much information as you can.

All information provided by you will be kept confidential.

Thank you for your participation.

Demographic Information	**Question type**	**Attribute**
26. Division a. Central b. Eastern c. Northern d. Western e. National	Dropdown	
27. Position a. Surveillance Officer	Dropdown	
EWARS Purpose	**Question type**	**Attribute**
6. What do you think is the purpose of the Early Warning Alert and Response System (EWARS)?	Comment box	Aim and objective
7. Do you think EWARS has had any impact on public health in Fiji? a. Yes, please specify: b. No c. Unsure	Multiple choice – single answer Comment box	Public health importance
EWARS System	**Question type**	**Attribute**
8. In your opinion, how easy is it to use EWARS? a. Very easy b. Somewhat easy c. Not very easy d. Not at all easy (very difficult)	Multiple choice – single answer Comment box	Acceptability

Follow up question for responses c or d: Which aspect of EWARS do you find most difficult?		
9. Have you ever had difficulty accessing the EWARS website? a. Yes b. No c. Not sure	Multiple choice – single answer	Stability
10. If yes, how often has this occurred? a. Very often *(most weeks)* b. Somewhat often *(more than once a month)* c. Not very often *(less than once a month)* d. Not at all often *(twice or less)*	Multiple choice – single answer	Stability
EWARS Receiving Reports	**Question type**	**Attribute**
11. In your opinion, how timely are the reports submitted from the health facilities in your division/s? a. Very timely *(almost always submitted by 6pm on Monday)* b. Somewhat timely c. Not very timely d. Not at all timely *(almost always submitted late)*	Multiple choice – single answer	Timeliness (reports)
Follow up question: What do you think are the main reasons why the reports are not submitted on time?	Comment box	
12. How often do you correct errors in the reports submitted by the health facilities in your division/s? a. Very often *(most weeks)* b. Somewhat often *(more than once a month)* c. Not very often *(less than once a month)* d. Not at all often *(twice or less)*	Multiple choice – single answer	Data validity
13. In your opinion, how accurately are the syndrome case definitions applied at the health facilities in your division/s? a. Very accurately a. Somewhat accurately b. Not very accurately c. Not at all accurately	Multiple choice – single answer	Data validity

Follow up question for responses c and d: What do you think are the reasons why the case definitions are not being applied accurately?	Comment box	
EWARS Verifying Alerts	**Question type**	**Attribute**
14. Please briefly describe how EWARS alerts are verified and actioned in your division/s (process of verification)	Comment box	Process flow
15. In your opinion, what are the most common challenges for timely verification of alerts? a. Unable to contact health facility b. Unable to speak with Medical Officer c. Unable to link number of cases to clinical records d. Unsure e. Other, please specify:	Multiple choice – multiple answer	Timeliness (alerts)
EWARS Syndromes	**Question type**	**Attribute**
16. Do you think the number of syndromes reported to EWARS is appropriate? a. Yes b. No – too many syndromes c. No – too few syndromes d. Not sure	Multiple choice – single answer	Simplicity
17. How easy was it to amend the surveillance process when an additional syndrome (Zika-like illness) was added to EWARS? a. Very easy b. Somewhat easy c. Not very easy d. Not at all easy *(very difficult)* Follow up question for responses c and d: Why was it difficult to amend the surveillance process when Zika-like illness was added?	Multiple choice – single answer	Flexibility
Event Based Surveillance	**Question type**	**Attribute**
18. How well do you think Event Based Surveillance (EBS) has been integrated into EWARS? a. Very well b. Somewhat well c. Not very well d. Not at all well e. Unsure	Multiple choice – single answer	Process flow / EBS

EWARS Usefulness	Question type	Attribute
19. How well do you think EWARS is able to signal an early warning for potential disease outbreaks? a. Very well b. Somewhat well c. Not very well d. Not at all well	Multiple choice – single answer	Usefulness
20. Do you receive the EWARS Weekly Bulletin? a. Yes b. No c. Unsure	Multiple choice – single answer	Usefulness
21. How useful is the information in the EWARS Weekly Bulletin in assisting you in your role? a. Very useful b. Somewhat useful c. Not very useful d. Not at all useful	Multiple choice – single answer	Usefulness
22. How could the EWARS Weekly Bulletin be improved so that it is more useful for your role?	Comment box	Usefulness
23. How do you use the information in the EWARS Weekly Bulletin?	Comment box	Usefulness
24. Do you ever distribute the information in the EWARS Weekly Bulletin to others? a. Yes b. No c. Unsure	Multiple choice – single answer	Usefulness
Follow up question for response a: Who do you distribute the information in the bulletin to?	Comment box	Usefulness
EWARS Training and Support	**Question type**	**Attribute**
25. How satisfied do you feel with the training that you received when EWARS was implemented? a. Very satisfied b. Somewhat satisfied c. Not very satisfied d. Not at all satisfied	Multiple choice – single answer	Acceptability
26. How supported do you feel to be able to carry out your EWARS responsibilities? a. Very supported b. Somewhat supported c. Not very supported d. Not at all supported	Multiple choice – single answer	Acceptability

EWARS Overall	Question type	Attribute
27. Overall, how satisfied are you with EWARS? a. Very satisfied b. Somewhat satisfied c. Not very satisfied d. Not at all satisfied	Multiple choice – single answer	Acceptability
28. Do you think surveillance using EWARS should be continued in Fiji? a. Yes b. No c. Not sure	Multiple choice – single answer	Acceptability / Sustainability
29. Any further comments?	Comment box	

Chapter 6 - Teaching

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Abbreviations

FETPNG	Field Epidemiology Training Programme in Papua New Guinea
LFF	Lesson from the field
MAE	Master of Philosophy (Applied Epidemiology)
PNG	Papua New Guinea
TEPHINET	Training Programs in Epidemiology and Public Health Interventions Network
WHO	World Health Organization

6.1 Prologue

6.1.1 Master of Philosophy (Applied Epidemiology) core activity requirements

This chapter fulfils the Master of Philosophy (Applied Epidemiology) (MAE) program requirement to complete two teaching components:

- A 'Lesson from the field' (LFF) – a peer teaching exercise based on challenges encountered in the field
- A teaching session for the first-year MAE cohort – a group-based teaching session for first year trainees on a topic that would be valuable as they begin their placements

This chapter also details my teaching experiences with the Field Epidemiology Training Programme in Papua New Guinea (FETPNG).

6.1.2 Teaching experiences and my role

6.1.2.1 Teaching and mentoring in Papua New Guinea

I was involved in the teaching of the Field Epidemiology Training Programme in Papua New Guinea (FETPNG) as a part of my placement at Hunter New England Population Health and in collaboration with the World Health Organization (WHO). The FETPNG program is currently in its fifth year of operation and trains approximately 15–20 fellows each year. I was fortunate to be involved in the teaching and mentoring of Cohort 4 (2016) and Cohort 5 (2017). The FETPNG program covers a range of content areas outlined in **Appendix 6.1**. In addition to lectures, the teaching phases include dedicated one-on-one mentoring time that increases with each phase. Mentoring enables the fellows to have dedicated technical support on their chosen projects and continues throughout the duration of the training program (~9 months). The FETPNG program is a unique field epidemiology training program in that it includes a phase dedicated to completing a public health intervention to try and resolve or improve an identified public health problem.

As a faculty member for the FETPNG program, I was involved in delivering lectures, leading case studies, mentoring fellows and providing support to the three training phases conducted in April, August and November each year (**Appendix 6.2**). I delivered lectures on a range of topics, including:

- Intro to Epidemiology

- Intro to Public Health Surveillance (II)
- Measures of Frequency
- Hypothesis Generation and Epidemiological Comparisons
- Screening: Sensitivity, Specificity and Predictive Values
- Review of Field Epidemiology Concepts

The FETPNG program is still in its early development and the program team is keen to continually improve the curriculum and course structure. I collected and collated feedback from the fellows during each phase and fed this back to the faculty. I was also involved in revising lecture content where appropriate.

My role included mentoring approximately three students throughout the duration of the training program each year. Fellows are able to design projects on any topic that is related to their work, which meant that I provided epidemiological support in a variety of program areas. The topics of fellows that I mentored are listed below:

- Factors Enabling Supervised Delivery within Catholic Health Services of Southern Highlands Province, May–June 2016
- Evaluation of the Diabetes Surveillance System in the National Capital District
- Improved management of MDR-TB in Hiri District
- HIV testing and Antiretroviral Therapy (ART) Uptake among TB patients at Enga Provincial Hospital, 2014-2016
- Barriers to Supervised Deliveries among women in Wain Constituency, Nawaeb District, 2016
- Suspected Dengue Fever Outbreak at a Secondary School in Kairuku District from April to July, 2017

This teaching experience was incredibly rewarding and challenged me to apply epidemiological methods that would be effective in low resource settings. I was also fortunate to be able to support a delegation of FETPNG fellows who presented at the 9th Global TEPHINET Conference in Chiang Mai, Thailand in August 2017 (photo of the FETPNG delegation in **Appendix 6.2**).

6.1.2.2 Lesson from the field

The topic I chose for my LFF was 'Using online questionnaires for outbreak investigations.' I was involved in a number of outbreak investigations during my placement at Hunter New England Population Health and I worked with my innovative OzFoodNet colleagues to try and maximise the efficiency and accuracy of case follow-up through the use of online questionnaires. Whilst developing online questionnaires may initially seem simple, we encountered a number of complexities around question structure, wording and questionnaire flow. This becomes even more difficult when trying to convert a standardised paper-based questionnaire into an online format. I felt it would be useful to talk through these complexities with my MAE cohort so that that those considering using online questionnaires could understand the benefits and limitations of this method (**Appendix 6.3** and **Appendix 6.4**).

6.1.2.3 Teaching session for the first year MAE cohort

The teaching session for the first year MAE cohort was developed with my MAE colleagues Siobhan St George and Katherine Todd. We each had our own experiences with outbreak investigations and we decided to present a session on 'Outbreaks 2.0: What we wish we knew before we did our outbreak investigation.' My contribution to this teaching session included tips on how to conduct an effective interview with a case, where to find appropriate guidelines and questionnaires and how to approach an investigation when the agent is unknown. Siobhan contributed information on legislation and guidelines on what is appropriate to disclose during investigations. Katherine contributed information on the legal implications of outbreak investigations and the balance of gathering sufficient evidence and initiating public health action. The presentation slides for this teaching session are provided in **Appendix 6.5**.

Appendix 6.1: Field Epidemiology Training Programme in Papua New Guinea (FETPNG) Training Schedule

Phase I	
Lectures	
Intro to Epidemiology	Outbreak Investigations (I, II, III)
Intro to Public Health Surveillance (I, II)	Changing and Strengthening Surveillance Systems
Event Based Surveillance in PNG	Intro to Public Health Intervention Methods
Measures of Frequency (I, II)	Measures of Central Tendency
Intro to Excel	Sampling Exercise
Surveillance Evaluations	Measures of Dispersion
Descriptive Epidemiology (I, II)	Analysing Surveillance Data
Scientific Communication (I, II, III)	Questionnaire Design
Screening: Sensitivity, Specificity and Predictive Values	Hypothesis Generation and Epidemiological Comparisons
Case Studies	
Surveillance Evaluation of Encephalitis	Outbreak Investigation: Cholera
Analysis of HIV Surveillance	Outbreak Investigation: Fever and Diarrhoea at a School
Phase II	
Lectures	
Review of Field Epidemiology Concepts	Monitoring and Evaluation
Designing Public Health Interventions	
Case Studies	
Public Health Interventions Exercise	Monitoring and Evaluation Exercise
Phase III	
Lectures	
Intro to Rapid Response Teams	Follow up courses and opportunities

Appendix 6.2: Photos of FETPNG training phases, 2016–2017

Giving lectures on epidemiological concepts and methods (and encouraging audience participation with treats)

Facilitating fellows' project presentations and discussions

Running a small group case study activity with James Flint

FETPNG Cohort 4 and Faculty, 2016

FETPNG Cohort 5 and Faculty, 2017

FETPNG delegation to the 9th Global TEPHINET Conference, Chiang Mai, Thailand, 2017

Using online questionnaires for outbreak investigations

Teleconference Instructions

Julie's LFF
Thu, 15 Jun 2017 2:00 PM - 4:30 PM AEST

Please join my meeting from your computer, tablet or smartphone.
https://global.gotomeeting.com/join/155557173

You can also dial in using your phone.
Australia: +61 2 8355 1020

Access Code: 155-557-173

First GoToMeeting? Try a test session: https://care.citrixonline.com/g2m/getready

Learning Objectives

By the end of this Lesson from the Field participants should be able to:

- Identify the benefits of using online questionnaires for outbreak investigations
- Identify the barriers to using online questionnaires for outbreak investigations
- Describe question and structure considerations when designing online questionnaires

Introduction

Questionnaires are a great way of systematically collecting data during an outbreak investigation. For many infectious diseases, standard questionnaires have been developed by Australian states and territories to collect information on known risk factors. However, each outbreak setting is different and may require additional, more specific, questions to be developed.

The way in which you develop your questions will have an impact both on the data collection process (ie. whether or not a respondent understands your line of enquiry and what information you are really after) and your ability to analyse your data. I can attest to having made mistakes in both of these areas!

As outbreaks often occur in a time-pressured environment, it can be difficult to think objectively about the way that questions are being asked. This Lesson from the Field aims to get you thinking in advance about the best way to ask questions and the most appropriate format for online questionnaires.

Online questionnaires: pros and cons

Online questionnaire tools offer a number of benefits during outbreak investigations:

- Easy circulation to participants who have access to internet;
- More timely responses;
- Higher response rates (sometimes);
- Reduced administrative time due to data entry;
- Reduced data entry error.[2]

Despite the benefits listed above, outbreak investigations in Australia are still primarily conducted using paper-based questionnaires. Below are some of the barriers to integrating online questionnaire tools in outbreak investigations:

1. For the hypothesis generating stage of an investigation, online questionnaire tools are not able to provide important qualitative data that could be obtained through telephone or face-to-face interviews;
2. Depending on the demographic profile of those involved in the outbreak, an online questionnaire tool may not be easy for people to complete (eg. elderly populations or those without access to internet);
3. Depending on how the outbreak is identified, it may not be possible to send a link to an online questionnaire (eg. outbreaks identified through routine surveillance rely on laboratory reports that include telephone numbers but not email addresses);

4. Online questionnaire tools require health jurisdictions to install appropriate software and train staff on their use;
5. Online questionnaire tools are often hosted on external or cloud-based servers that do not comply with national or state and territory based privacy legislation.

Scenario

You are an Epidemiologist working at a Public Health Unit in New South Wales. You receive a complaint from a local primary school teacher who attended a weekend teacher's retreat at a rural property in your area from 27-28 May 2017. The teacher said she fell ill with a gastrointestinal illness 2 days after being at the retreat and she was aware of other teachers who had been sick also. She had gone to her local GP who had taken a stool specimen. The specimen was positive for *Campylobacter*.

The teacher provided details of a range of activities that occurred during the retreat. As a team building exercise, the teachers participated in a tough mudder exercise course on the first day. It was noted that the course crossed through paddocks that also had cows and sheep. This was followed by a relaxing night with wine, cheese and chicken liver pâté as the property was also a winery. She also mentioned that that the owner of the property's dog had recently had puppies which she and other teachers had played with.

The retreat was organised by a section within of the Department of Education. You get in contact with them and learn that the teachers who attended the retreat were from selected schools throughout NSW. They have also started receiving complaints of teachers being sick following the retreat. They indicate that the only communal activity was the tough mudder exercise course and the only communal meal was the wine and cheese night.

The organisers are not willing to provide the names or contact details of the teachers who attended the retreat. However, they are happy to send an email to the teachers with some information and a link to an online questionnaire.

Your colleagues at the Public Health Unit recall that an online questionnaire was created in SurveyMonkey for a previous outbreak of *Campylobacter* at a restaurant. You decide to review this questionnaire and see whether it could be modified for the current investigation.

Campylobacter Resources

- *Campylobacter*iosis fact sheet (New South Wales): http://www.health.nsw.gov.au/Infectious/factsheets/Pages/*Campylobacter*iosis.aspx
- *Campylobacter*iosis case questionnaire (Victoria): https://www2.health.vic.gov.au/about/publications/researchandreports/Case%20questionnaire%20for%20*Campylobacter*iosis
- *Campylobacter* case questionnaire (Queensland): https://www.health.qld.gov.au/__data/assets/pdf_file/0025/444904/questionnaire-*Campylobacter*.pdf

Task 1

Review the questions from the online survey used for the previous outbreak at the Hunter Valley Fake Pizzeria.

Web link: https://www.surveymonkey.com/r/QFNLXBG

Note down any problems that you find with the way that questions are being asked, the response types or the progression of questions.

Scenario Update

Due to the numerous problems that you found with the previous outbreak questionnaire, you decide to start from scratch and build a new questionnaire for the current investigation using SurveyMonkey.

You discuss the information that you want to collect with your colleagues and come up with a list of question areas.

Task 2

Create a questionnaire for the current *Campylobacter* investigation in SurveyMonkey using the question areas on the next page.

Think about the best way to ask the question, the most appropriate response type and any necessary skip patterns / question progressions based on people's responses.

Web Link: https://www.surveymonkey.com/user/sign-in/

SurveyMonkey Login:

Username: ……..

Password: ……...

Please title the questionnaire with your name in SurveyMonkey. (Eg. Julie – Teacher's Retreat Questionnaire)

SurveyMonkey Resources

- JC_LFF_SurveyMonkey_Instructions.pdf
- SurveyMonkey Help Centre: https://help.surveymonkey.com/

Question areas for online questionnaire

	Demographic Information	
1	Date of birth	
2	Sex	
3	State of residence (NSW, ACT etc)	
	Retreat Attendance / Unwell	
4	Did the person attend the retreat?	
5	Has the person been unwell since attending the retreat?	
	Clinical Information (if unwell)	
6	What was the first symptom experienced?	Date / time of onset of first symptom
7	Did the person have the following symptoms:	
-	Diarrhoea	If yes to diarrhoea:
-	Nausea	Was it watery or bloody diarrhoea?
-	Vomiting	Date / time onset of diarrhoea
-	Fever	Duration of diarrhoea
-	Abdominal pain	
-	Lethargy	
-	Headache	
-	Other (please specify)	
8	What was the total duration of the person's illness?	
	Food Consumption	
9	Did the person attend the communal wine and cheese event on Saturday 27 May 2017?	
	If yes, did they eat the following foods:	
-	Brie cheese	
-	Camembert cheese	
-	Quince paste	
-	Chicken liver pâté	
-	Jamón Ibérico	
	Outdoor Activities	
10	Did the person participate in the tough mudder obstacle course event on Saturday 27 May 2017?	
	Animal Contact	
11	Did the person have any contact with the following animals whilst at the retreat?	

-	Dog / puppy	If yes to dog / puppy:
-	Cat / kitten	Specify type of contact
-	Cow	
-	Horse	
-	Sheep	
-	Goat	

References

1. Boynton PM, Greenhalgh T. Hands-on guide to questionnaire research: Selecting, designing, and developing your questionnaire. BMJ: British Medical Journal 2004;328(7451):1312-5.

2. Parry AE, Johnson DR, Byron-Gray K, Jane CAR, McPherson M. Online Questionnaires for Outbreak Investigations. Epidemiology 2011;22(6):875-6.

Examples of online questionnaire use in outbreak investigations

1. Stuart Chester TL, Taylor M, Sandhu J, Forsting S, Ellis A, Stirling R, et al. Use of a web forum and an online questionnaire in the detection and investigation of an outbreak. Online journal of public health informatics 2011;3(1). DOI: http://dx.doi.org/10.5210/ojphi.v3i1.3506

2. Griffiths SL, Salmon RL, Mason BW, Elliott C, Thomas DR, Davies C. Using the internet for rapid investigation of an outbreak of diarrhoeal illness in mountain bikers. Epidemiology and Infection 2010;138(12):1704-11. DOI: https://doi.org/10.1017/S0950268810001561

3. De Jong B, Ancker C. Web-based questionnaires - a tool used in a *Campylobacter* outbreak investigation in Stockholm, Sweden, October 2007. Eurosurveillance 2008;13(17). Available online: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=18847

Appendix 6.4: Lesson from the field Task 1 – Hunter Valley Fake Pizzeria Outbreak Questionnaire design flaws

General questionnaire flaws

- The questionnaire does not have any skip patterns (or page logic). Skip patterns are helpful as they allow participants to only see certain questions based on their previous responses.
  For example: If someone ticks 'no' to diarrhoea, then they are not shown a question asking when their diarrhoea began.

- The questionnaire is structured to collect information on restaurant attendance and food consumption prior to clinical information. For an outbreak setting such as a restaurant, this is fine – although generally clinical symptoms are collected prior to exposures.

- Page numbers, question numbers and progress bars are not generally included in online questionnaires. It is best to give participants an indication of the time it will take to complete the questionnaire in the introduction section, prior to them completing the questionnaire.

  - Mica: consider having a number for the overall category and then letter for additional questions within that category.

- It is often good to include a title page, end of survey page for your survey. A page requesting 'any additional information' also allows the participant to provide information that they haven't had a chance to during the survey. Useful for acceptability, even if the data cannot be analysed.

  - Siobhan: Difficult to make decisions when you don't want to collect that data for the analysis, but the respondent potentially wants to provide that info.

Question specific flaws

Page 1

1. **Name:**

- Names are not generally collected for online questionnaires, unless the investigators are hoping to go back and contact the participant. (picked up by Laura)
- First name and last name should be separated. (picked up by Rose)

2. **Age:**

- Date of birth is usually used as a more accurate way of calculating age. (Picked up by Rose)
- The question type is a single text box. There should be a requirement for the answer to be in a number format (Options – Validate Answer for a Specific Format).

3. **Gender:**

- Sex (biological differences) is generally used in surveillance and outbreak collection tools, rather than gender (socially defined differences).
  In 2016, the Australian Bureau of Statistics updated their standard question for sex to include an 'Other' option, with a follow on question asking participants to 'please specify.'
  (http://abs.gov.au/ausstats/abs@.nsf/latestProducts/1200.0.55.012Media%20Release12016)

  - Rose: interesting way asking about sex was used in a HIV study that asked respondents for sex at birth and sex now.

Page 2

4. **Did you eat at the Hunter Valley Fake Pizzeria on 30/04/2016?**

- When asking about dates, it is good to include the week to give people a reference. Also, as a personal preference, I feel it is easier for people to think about months as words rather than a numeric value.
  Eg: Friday, 30 April 2016.

5. **What date and time did you eat at the restaurant?**

- This question is repeating the date component. Also, there should be a requirement for time to be in a time format. (picked up by Siobhan/Katherine)

Page 3

6. **What did you eat at the Hunter Valley Fake Pizzeria?**

- The question includes overall categories (eg. pizza) and then subcategories. It would be better to separate this and have subcategories showing only if the person ticks yes to the overall category.
- It is important to have a 'Don't know/unsure' response category for food recall. (Picked up by Siobhan/Katherine)

- The layout of this question is confusing. It would be better to have foods listed as rows and the responses listed as columns. (picked up by Mica)
- The question has not specified a requirement for single responses to each food category. Therefore participants can pick yes and no to a food item – reducing the quality of data. (picked up by Katherine)

7. **If you had chicken, did it seem undercooked to you?**
   Leading question which may bias participants. If chicken is a suspected item, it would be better to ask this in a more neutral way. Also, a 'Don't know' response category should be included. (picked up by Mica)

Page 4

8. **When did you feel sick?**

- Poorly worded question. This is a free-text response. The question should specify that the answer needs to be a date. (Siobhan – better to ask about the date of the first symptom)

9. **Did you have the following symptoms?**

- Too many response columns. Reduce to fit the question.

10. **When did your diarrhoea start?**

- This is a joint response for date and time, which will transfer into one column in Excel when exported. For analysis, it would be better to break this up into two questions.

11. **How long were you unwell for?**

- Need to specify the units (hours, days, weeks). This is a free-text response box and should include a requirement for the answer to be a numerical value. (Picked up by Siobhan/Rose – ask when the symptoms ceased – "unwell" is ambiguous.

12. Did your doctor give you antibiotics?

- The wording of this question may mean that participants don't respond in the desired way. For example, if a person went to the hospital and did not see 'their' doctor, they might answer 'no' even though they did receive antibiotics from the hospital doctor.
  (Also picked up by Siobhan – should ask people if they took the antibiotics, as they might have been prescribed but never taken)

13. Do you know of anyone else who ate at the restaurant and has been sick?

- The response to this question is in a different order to the previous questions. It is important to be consistent in response order so that participants don't get confused.

14. Provide the details of other people who have been unwell:

- Privacy issues around this question. Comment box is difficult to analyse, but useful for additional qualitative information.

Appendix 6.5: Lesson for first year MAE cohort – Outbreaks 2.0

Outbreaks 2.0

What we wish we knew before we did our outbreak investigations!

Julie Collins, Siobhan St George, and Katherine Todd

Let's talk about…

OZ FOOD NET

ozfoodnet

Learning objectives

- Be aware of practical considerations and resources for interviewing cases
- Recognise the legislative frameworks governing outbreak investigations
- Identify the type of information that may be disclosed during an outbreak investigation
- Recognise legal considerations during an outbreak investigation
- Explain the weight of evidence in making decisions about outbreaks

Interviewing Tips

- Know your questionnaire
  - Information will not always come chronologically
- Know the public health information available
  - Fact sheets
- Know some basic information about your case
  - Date of specimen collection
  - Have a calendar!!
  - Map

Interviewing Tips

- Don't assume that people know who you are or why you're calling
  - Multiple healthcare providers / results not always given
  - Notification delay
- Explain your line of questioning
  - "I'm now going to ask some questions about your illness…"
- Take the time to build rapport
  - May not be the last time you need to speak with that person

What information should you collect?

- Do you know the agent?
  - Specific questionnaires / guidelines
- Do you have a hypothesis?
  - *Salmonella* trawler vs. priority trawler

- What if you don't know what you're dealing with?
  - Be as systematic as possible to allow comparison
  - Draw on previously established questionnaires to capture information (demographics, travel, food)

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

OzFoodNet
Communicable Disease Control
Case Questionnaire

Shigella

ATTEMPTS TO CONTACT CASE

Date	Time	Comments

PRIVACY MESSAGE:

Resources

Queensland Government

Home > Infectious diseases > Control Guidelines > Cholera control guideline

Cholera control guideline

Control guidelines
Fact sheets
A-Z of infectious diseases

Control Guideline for Public Health Units

Public health priority: High

PHU response time: Respond to probable and confirmed cases within day of notification. Enter confirmed cases on NCIMS within 1 working day.

Case management: Case usually needs fluid and electrolyte replacement. Identify likely source of infection. Notify Communicable Diseases Branch.

Contact management: Contacts who were exposed to the same source of infection should be advised of the risk.

Last updated: 01 July 2012

1. Reason for surveillance
2. Case definitions

Resources

Find the experts!

Photo removed due to confidentiality

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

167 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

Udo Boschan, pictured at a previous court appearance.

Former bakery director Udo Boschan has been ordered to pay $15,000 in costs, in the closing chapter of a court case over

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

"C'mon, c'mon — it's either one or the other."