Communicable Disease Control in the Australian Capital Territory

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A thesis submitted for the degree of Master of Philosophy in Applied Epidemiology

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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 ANU or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at NSW Health or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project’s design and conception or in style, presentation or linguistic expression is acknowledged.

Signed

November, 2017
Acknowledgments

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Abstract

The ACT Health, Communicable Disease Control Section (CDCS) is responsible for the surveillance, investigation and public health management of notifiable diseases in the Australian Capital Territory (ACT). In this thesis, I present work conducted as a Master of Philosophy in Applied Epidemiology (MAE) scholar, whilst placed at the CDCS for the period of 2016–2017. During my placement, I was involved in routine disease surveillance and investigation activities on a daily basis, and completed the competencies aligned with the MAE program.

One such requirement is the analysis of a public health dataset. In the ACT notifications of influenza has increased in recent years. To better understand the epidemiology of influenza in the ACT, I analysed influenza notification and test data over an 11-year period. The analysis confirmed increases in notifications, and tests were independent of increases in test positivity. Findings also identified differences in case characteristics and the positive test rate, depending on the testing pathology laboratory. The analysis supports the recommendation that influenza surveillance in the ACT would be strengthened by introducing negative test reporting.

For my epidemiological study I present a time series analysis of different temperature metrics and notifications of enteric disease in the ACT. Associations better temperature and salmonellosis and cryptosporidiosis notification incidence were found using different metrics of temperature. These findings were consistent with previous research for all diseases; and comparison of different temperature metrics suggest a temperature measure accounting for recent past temperature trends may be a useful predictor of enteric infection.

During my placement in CDCS – the section responsible for conducting outbreak response, most commonly foodborne - offered me multiple opportunities to meet the outbreak investigation MAE requirement. Here, I present an outbreak of Salmonella Typhimurium associated with a Canberra café where two waves of cases with distinct MLVA profiles were identified. The epi-curve suggested an intermittent exposure source over multiple weeks and a case-control study and environmental investigated indicated widespread contamination of the café as the cause of the outbreak. In the appendices to this bound volume I also present two additional outbreak investigations from my placement. An acute response case-series investigation of gastroenteritis in a visiting school group from Queensland focused on detailing illness characteristics to inform public health decision making in lieu of pathology testing. And an cohort study following a report of multiple
cases of acute gastroenteritis of unknown aetiology in people who attended a wedding. The investigation hypothesised person-to-person transmission to likely be the source after no food items were found to have a significant association with illness.

In the final chapter, for my evaluation project, I present an assessment of varicella zoster virus (VZV) surveillance in the ACT. Considering the introduction of the National Shingles Vaccination Program in late 2016, prompted the evaluation to measure the system’s performance. As part of the evaluation, I identified deficiencies in the system that could be readily overcome to improve the quality of surveillance undertaken in the ACT and presented recommendations to improve surveillance effectiveness moving forward.

Overall this bound volume is representative of two years of learning and skill development, providing documentation of my MAE placement at ACT Health and my contributions to the territory’s public health system, community and research.
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Introduction
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Field Placement

I was placed in the Communicable Disease Control Section (CDCS) at ACT Health to undertake my MAE. Organisationally, within ACT Health the CDCS is positioned within the Health Protection Service (HPS) which comprises of an Environmental Health Section (EHS), Environmental Policy section, the ACT Government Analytical Laboratory (ACTGAL), Pharmaceutical Services section, Business Managements and Administrative Services. The aim of the HPS is to protect and promote the health of the ACT community through innovative and timely actions; In turn the primary role of the CDCS is to:

“minimise the harm caused by the spread of communicable diseases”

The CDCS is comprised of three sub-sections:

Surveillance: responsible for the surveillance, investigation and public health management of notifiable diseases along with being responsible for the management of outbreaks.

Infection control: audits premises that conduct public health risk activities to ensure compliance with infection control standards.

Immunisation: responsible for the coordination of the ACT immunisation program and the development of ACT Health communicable disease and immunisation policy.

In my role as the MAE scholar, I worked primarily in the surveillance team, but also liaised closely with the other CDCS teams during routine surveillance and public health follow up. I also worked with EHS and ACTGAL extensively during outbreak investigations.

Routine surveillance activities that I regularly participated in included data entry, and case follow-up of notifications for arboviruses, vaccine preventable and enteric diseases. This included interviewing cases and collecting enhanced information from clinicians. I also had the opportunity to provide additional support to the CDCS on an ad-hoc basis. This work included undertaking literature reviews, assisting in the development and running of an outbreak investigation workshop led by the OzFoodNet epidemiologist, and involvement in the development and updating of Standard Operating Procedures (SOP). Notably, this

1 ACT Health Annual Report 2014–2015
involvement included assisting with the development of SOPs for public health response to infectious disease threats imported on international flights in preparation for Canberra Airport becoming an international airport. Finally, I also took part in discussions regarding the development of a new notifiable disease database for the CDCS.

**Public Health Impacts**

In my role I was able to contribute to the routine public health impacts of the CDCS. In addition, the projects undertaken during my placement also contributed to improving and protecting public health in the ACT.

The introduction of varicella vaccine to the National Immunisation Program in 2005 highlighted the importance of collecting quality surveillance data for varicella. With the introduction of the National Shingle Vaccination Program in late 2016, it was important to consider the quality of the ACT’s ability to surveillance varicella zoster virus. The recommendations from the evaluation I undertook aim to strengthen the surveillance capacity for varicella zoster virus and allow for improved public health response as varicella cases become increasingly rare. The recommendations also aim to assist in capturing data that will be useful in measuring the vaccine impact of Zostavax® on increasing herpes zoster notification rates.

The data analysis of influenza notification and test trends produced findings that were shared with the CDCS and the Office of the Chief Health Officer. These findings highlighted limitations in current influenza analysis and reporting practices in the ACT. Through discussing these results, subsequent recommendations were developed which were directed at improving reporting practices. This is particularly important for influenza, where public health messaging and availability of accurate data for evidence-based decision making can have a substantial impact on reducing the overall disease burden.

Studying the relationship between heat and enteric infection in the ACT will hopefully provide a valuable resource to inform risk reduction messaging for salmonellosis, campylobacteriosis and cryptosporidiosis. By looking at different temperature metrics the study also adds to the body of literature on the relationship between climate and infectious diseases. I had initially planned to study the association between heat and general morbidity using hospitalisation data to inform revision of the ACT Extreme Health Plan. Although I
was unable to undertake this research project, the proposal and data analysis plan that was developed will hopefully be of use to ACT Health in the future.

Foodborne outbreak investigation is part of the routine work of the CDCS, EHS and ACTGAL teams at HPS. Being part of the multiple outbreak teams, I contributed to identifying sources of outbreaks and ensuring that appropriate public health action was able to be undertaken to mitigate unnecessary public health risk and reduce the burden of foodborne illness in the ACT population.
Master of Philosophy (Applied Epidemiology) requirements

I have completed the following requirements for the qualification of Master of Philosophy (Applied Epidemiology).

Field projects

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<tr>
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<th>Epidemiology of influenza notifications and tests in the Australian Capital Territory, 2005–2015 (Chapter 2)</th>
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</thead>
</table>
| Field investigation of an acute public health problem or threat (outbreak) | A case series analysis of gastroenteritis among a visiting school group to the ACT (Chapter 4)  
A cohort study of gastroenteritis among wedding attendees at a wedding and a barbecue breakfast (Chapter 4)  
Salmonella Typhimurium outbreak of multiple MLVA types at a café in Canberra, February 2017 (Chapter 4) |
| Epidemiological study | Exploring the relationship between heat and enteric infection in the Australian Capital Territory using different temperature metrics (Chapter 3)  
Measuring climate variability, weather and hospitalisations in the Australian Capital Territory: Study proposal (Chapter 3) |
| Public health surveillance system establishment or evaluation | Evaluation of Varicella-Zoster Virus notification surveillance in the Australian Capital Territory (Chapter 5) |

Additional requirements:

| Literature review | A literature review was completed for each of the field projects listed. |
| Report to a non-scientific scientific audience | ACT Playgroups Association ‘ACTive Play Newsletter-Keeping your child healthy – Viral gastroenteritis’: article/factsheet (Appendix B)  
| Preparation of advanced draft of a paper for publication | Salmonella Typhimurium outbreak of multiple MLVA types at a café in Canberra, February 2017 (Chapter 4)  
Exploring the relationship between heat and enteric infection in the Australian Capital Territory using different temperature metrics (Chapter 3) |
| Oral presentation(s) | McEwen S, Lal A, Roberts-Witteveen A, Kaczmarek |
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<thead>
<tr>
<th>Teaching</th>
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| Lesson from the field | The basics of preparing a time series analysis: extracting and using climate data for basic time series analysis. Conducted via teleconference; 8 June 2017 (Appendix A) |

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<thead>
<tr>
<th>Coursework</th>
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<tbody>
<tr>
<td>POPH 8915 Outbreak Investigation</td>
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<tr>
<td>POPH8917 Public Health Surveillance</td>
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<tr>
<td>POPH8913 Analysis of Public Health Data</td>
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Chapter 2

Epidemiology of influenza notifications and tests in the Australian Capital Territory, 2005–2015
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Prologue

Role

The 2014 and 2015 influenza seasons in the ACT were substantially larger compared to other non-pandemic years. Because of this, the Communicable Disease Control Section (CDCS) at ACT Health was interested in reviewing the ACT’s influenza epidemiology. Prior to me beginning my placement, the section had been awarded an ACT Health, Population Health Division Research Support Grant providing funding for staff within the division to undertake research projects pertinent to health in the ACT. The grant funds allowed the CDCS to obtain influenza test data, including of negative tests, from two ACT-based pathology providers. The data analysis presented in this chapter utilised the availability of these data sets.

My role was to undertake a data analysis of influenza notifications and tests for the time period from when influenza became notifiable in the ACT in 2005, to the last complete year of data (2015). With support of my academic and field placement supervisors, I was responsible for designing the data analysis plan; cleaning, recoding and transforming the data ready for analysis; conducting the analysis; and presenting findings to relevant stakeholders, including the required reporting as stipulated in the terms of the awarded grant.

Ethics approval for the project had been granted previously. I was added as an investigator to the research team by request to the ACT Health Human Research Ethics Committee (HREC).

I presented the findings of the descriptive analysis at the 2016 Canberra Health Annual Research Meeting (CHARM) as a poster presentation and at the 2016 TEPHINET Regional Conference in Siem Reap, Cambodia as a short presentation. Findings of the statistical analysis for the project were presented as a ‘short oral’ presentation at the Public Health Association of Australia, Communicable Disease Conference, 2017 in Melbourne, Australia.

Lessons learnt

The opportunity to undertake this project as my data analysis provided me with a number of learning opportunities.
Firstly, I increased my skill-set in both data management and analysis. During the project I learnt the importance of, and how to make a data analysis plan. How to use statistical programs (Stata) to clean and recode data; and subsequently how to undertake descriptive and more complex analysis using Stata. Learning how to conduct a regression analysis for count data was also a valuable skill I was able to take away from the project.

Secondly, having never presented at a scientific conference before, the project gave me an opportunity to acquire a number of key academic presentation skills. The project’s acceptance into the South East Asia and Western Pacific Bi-regional TEPHINET Conference in 2016; the Public Health Association of Australia, Communicable Disease Control Conference in 2017; as well as being asked to present during MAE course block to peers, gave me a valuable opportunity to learn how to prepare an academic presentation, and, through each experience improve my presentation skills. Additionally, I learnt how to make an academic poster, which I presented at the Canberra Health Annual Research Meeting.

**Implications for public health**

The aim of this data analysis was to generate a better understanding of the epidemiology of influenza notifications in the ACT in light of recent increasing notifications. By identifying factors associated with notification and positive tests, the analysis provides context for how to better interpret surveillance trends. The findings from this study hope to inform how to best report influenza surveillance data captured by the notifiable disease surveillance system in the ACT. Accurate reporting of influenza is an important public health action that informs preparedness, resource allocation and risk communication to the community.

**Acknowledgements**

I would like to thank and acknowledge the following people for their assistance and involvement in this project.

My academic and workplace supervisors: Dr Aparna Lal, Ms Rebecca Hundy, Dr Marlena Kaczmarek and Ms April Roberts-Witteveen for their guidance, assistance, patience and expertise throughout this project.
All the staff from the Communicable Disease Control Section at ACT Health: Sue Reid, Rachel Crane, Milica Stefanovic, Jodie Huet, Ashleigh Keeling, Miranda Harris, Sam Kelly, Romaine Huggett and Sandy Wynn. Dr Ranil Appuhamy and Dr Vanessa Johnston.

The National Centre for Epidemiology and Population Health (NCEPH), Australian National University (ANU) MAE course coordinators.

**Master of Philosophy (Applied Epidemiology) core requirement**

This chapter is included in my bound volume to fulfil the Master of Philosophy (Applied Epidemiology) requirement of: Analysis of a public health data set.
Epidemiology of influenza notifications and tests in the Australian Capital Territory, 2005–2015

Abstract

Background

Only laboratory confirmed influenza is notifiable in the Australian Capital Territory (ACT). Without complete testing data it is difficult to assess whether changes in notification data reflect increased testing or patterns of incidence. This study analysed the proportion of positive tests and notifications to understand influenza trends in the ACT.

Methods

Notification data and test data were obtained from ACT-based pathology laboratories over an 11 year period. Patterns of influenza notifications and tests over time were described by demographic characteristics and differences between diagnostic methods and testing laboratory. Negative binominal regression was used to examine the associations of notifications and positive tests with age, sex, year, diagnostic method and testing laboratory.

Results

Notification and testing rates increased over time, with peaks in notification incidence and testing counts in 2009, 2014 and 2015. The incidence notifications peaked in those aged 0–4 and ≥80 whereas the incidence of positive test was lowest at 0–4 years and at ≥60 years. The incidence rate ratio (IRR) of notifications through PCR was significantly higher than other diagnostic methods, however the IRR of PCR positive tests was not different to serology. The IRR of notifications did not differ significantly between testing laboratory, while test positivity was significantly higher at one laboratory.

Conclusion

Discordance between test positivity and notifications indicate notification data interpreted alone may be subject to bias. Calculating the proportion of positive tests helps to provide a better understanding of notification trends, however, differences in test trends, and patient demographics between testing laboratories suggest the need to consider data from all laboratories. Trends in the proportion of positive tests also vary between pathology providers who serve either primarily hospitals or general practice. Interpretation of
influenza epidemiology in the ACT would benefit from negative test reporting from all servicing pathology laboratories.
Introduction

Influenza is an acute viral infection of the respiratory tract, characterised by symptoms of fever, cough (usually dry), headache, muscle pain, lethargy, coryza and sore throat.\(^1\) Complications arising from influenza infection can include viral and bacterial pneumonias, bronchitis and exacerbation of underlying chronic conditions, including asthma.\(^2\) Droplets produced from the cough or sneeze of an infected individual are an important mode of person-to-person transmission of the virus, and an important contributor to the high outbreak potential of influenza.\(^3\) The typical incubation period for influenza is 2 days, with a range 1–4 days. In adults, infected individuals are contagious from the day prior to onset and up to 3–5 days after onset\(^4\) and children are contagious from the day prior to onset and up to three weeks after.\(^4,6\)

The impact of influenza on populations is a significant public health concern.\(^7-10\) The World Health Organisation (WHO) estimates that influenza affects approximately 15% of the global population annually.\(^7\) In Australia, influenza is one of the leading causes of vaccine preventable morbidity and mortality each year\(^11-13\) and causes substantial financial burden to the Australian health care system.\(^12-14\) In temperate regions of Australia, influenza infection is consistently seasonal with increasing incidence between late autumn and early spring.\(^9,15\) Variation in the pathogenicity and infectivity of the circulating influenza virus strain influences the characteristics of the epidemiology of influenza seasons year to year.\(^15,16\) Therefore to understand the epidemiology of influenza, ongoing surveillance is required to assess the timing, circulating strain, magnitude, severity, and duration of influenza seasons.

In Australia, data used to assess the characteristics of seasonal influenza are captured by a number of different surveillance methods.\(^17\) Statutory notification of laboratory confirmed influenza was introduced in most states and territories in 2001; national reporting of notifications by all jurisdictions commenced in 2008.\(^17\) While national reporting of influenza notifications should allow comparisons of disease trends both between jurisdictions and within jurisdictions over time, laboratory confirmed notifiable disease surveillance systems do not capture every case in the community as not every case seeks care and/or is tested.\(^17,18\) Consequently notification counts are biased by variation in the overall number of tests performed, which may vary between jurisdictions and year to year.\(^17\) \(^19-21\) Although alternative surveillance systems in Australia for influenza do exist – such as sentinel general practice syndromic surveillance for influenza-like-illness (ILI),\(^22\) syndromic
surveillance of self-reported ILI in the general community\textsuperscript{23} and hospital based surveillance of severe or complicated influenza\textsuperscript{24} – these surveillance systems also have inherent limitations. ILI surveillance systems can lack specificity and national coverage,\textsuperscript{19, 23, 25} whereas hospital-based surveillance is dependent on adherence to procedures which may affect data quality and is influenced by patient health seeking behaviours which affects the sensitivity of the overall surveillance system.\textsuperscript{24} Moreover, these system are fragmented between states and territories and their representativeness is likely limited.\textsuperscript{26} Influenza surveillance reporting in Australia therefore generally uses a combined approach, incorporating available data from multiple surveillance systems to provide a picture of the underlying epidemiology of influenza each season.\textsuperscript{21}

Notification data are considered the primary source of influenza incidence data across Australia.\textsuperscript{17} By not considering testing variation either temporally or spatially, laboratory confirmed notification surveillance trends may overestimate or underestimate increases in actual disease incidence over time or between locations.\textsuperscript{19, 21} Variation in testing practice is itself likely to be biased by both clinician practices and patient health seeking behaviours,\textsuperscript{11, 21, 27} and influenced by accessibility to services, laboratory practices, increased media attention and health promotion campaigns.\textsuperscript{11, 21, 27} For example the introduction of Polymerase Chain Reaction (PCR) testing in Australia had subsequent effects on notifications.\textsuperscript{20} PCR was added to the Medicare Benefit Schedule (MBS) in 2005,\textsuperscript{28} and, in 2009, funding to pathology laboratories was made available to allow laboratories to purchase equipment, primarily to enhance PCR testing capacity.\textsuperscript{29} Faster, less invasive, cheaper and more accessible diagnostic methods with increased sensitivity such as PCR, have been hypothesised to have led to increased influenza testing, case ascertainment, and subsequently notifications nationally.\textsuperscript{19, 30} Calculating the proportion of positive tests from the total number of tests conducted provides a methodology to control for variation in testing frequency.\textsuperscript{19, 31} Test positivity is currently utilised in national influenza surveillance reporting, although data availability is limited to sentinel laboratories in some states.

An informed understanding of the factors influencing the interpretation of influenza surveillance data is needed. Misinterpretation of influenza epidemiology can risk compromising the community’s confidence in public health messaging, influencing health related behaviours, including vaccination.\textsuperscript{32} Misinterpretation can also threaten to misguide policy or public health decision making.\textsuperscript{21} In Australia, the 2015 influenza season was characterised by notification counts larger in magnitude than the 2009 A/H1N1 pandemic,
and attracted substantial media attention throughout the season, including prior to the peak. A review of multiple sentinel influenza-like illness (ILI) syndromic surveillance systems, including the voluntary online influenza-like-illness surveillance tool Flutracking\textsuperscript{1,2,3} and national laboratory confirmed notifications, concluded the 2015 influenza season, although larger by notification counts, was comparable to other post 2009 A/H1N1 pandemic seasons in terms of severity, duration and magnitude of ILI.\textsuperscript{21} These findings also suggested the number of tests, may have driven the high notification counts.\textsuperscript{21}

In the Australian Capital Territory large influenza seasons were also reported in 2014 and 2015.\textsuperscript{11} The ACT is a relatively small jurisdiction in Australia, with a largely urban population of around 400,000. Laboratory confirmed influenza became notifiable in the ACT in 2005, later than most other states or territories. Typically, trends in the ACT are not notably different from national influenza trends.\textsuperscript{33-35} The ACT has a temperate climate where typically the influenza season occurs during the cooler months between late autumn and early spring.\textsuperscript{9} Currently in the ACT, there are no pathology laboratories that participate in national sentinel laboratory surveillance of influenza.\textsuperscript{33} Influenza surveillance in the ACT consists of: notification of laboratory confirmed notifications; participation of ACT residents in Flutracking\textsuperscript{ii}; participation by the two major tertiary referral hospitals in the ACT to FluCAN\textsuperscript{iii}; participation of a small number of GPs in ASPREN\textsuperscript{iv}; mortality registers; and, informal reporting of test positivity data from one ACT-based pathology provider. Emergency department ILI presentation and hospitalisation data are not available.\textsuperscript{36} Influenza testing occurs through a mixture of public and private laboratories services. Notification and testing trends by demographic characteristics, diagnostic method or testing laboratory have not been previously explored in the ACT.

Aims and objectives
The current analysis aims to describe the epidemiology of influenza in the ACT and changes in notifications and tests between 2005 and 2015. The analysis explored differences in notifications and tests by demographic characteristics using test data from two ACT-based pathology laboratories, and notifications of all laboratory confirmed influenza. The

\textsuperscript{ii}Flutracking is a voluntary online syndromic (ILI) surveillance system uses an online platform to collect weekly reports of ILI by participants

\textsuperscript{iii}The influenza complications alert network (FluCAN) is a real-time sentinel hospital surveillance system for acute respiratory diseases requiring hospitalisation.

\textsuperscript{iv} The Australian Sentinel Practices Research Network (ASPREN) is a network of sentinel general practitioners and nurse practitioners which conducts syndromic surveillance of ILI (and other conditions) seen in general practice.
effect of changes in testing on influenza notifications between 2005 and 2015 were examined, focusing on diagnostic methods and variation in testing characteristics between testing laboratories.

**Research questions**

1. Has there been a change in the epidemiology of notified influenza cases in the ACT between over time?

2. Has there been a change in the epidemiology of influenza tests and positivity in the ACT over time, and have such changes likely affected the epidemiology of notified influenza cases?

**Methods**

**Data sources**

**Notifications**

Notifications of laboratory confirmed cases of influenza are reported to the ACT Health’s Notifiable Disease Management System (NDMS).

A laboratory confirmed case is defined by:

- isolation of influenza virus by culture, nucleic acid test (PCR) or virus antigen test from an appropriate respiratory tract specimen; or
- IgG serconversion (fourfold of greater rise in titre to influenza virus or significant increase in antibody level); or
- A single high titre by complete fixation test or haemagglutination inhibition to influenza virus.\(^{37}\)

Notification data capture demographic data of the case and reporting information such as the name of the testing laboratory, which here are coded to Laboratory A and Laboratory B to align with test data, and where notifications were from another laboratory coded as “other laboratory”. Notification data were extracted from the NMDS for the period 2005–2015.

**Laboratory testing data**

De-identified laboratory testing data for all influenza specimens from ACT residents was provided by two of the three pathology laboratories that service the ACT and together
account for 85% of influenza notifications received. The first laboratory, henceforth referred to as Laboratory A, is the public pathology provider, which provides services to public hospitals in the ACT. Data was available from this laboratory, for the period 2005–2015. The second pathology laboratory, henceforth referred to as Laboratory B, is a private pathology provider. Data from Laboratory B were available between 2005–2012.

Population estimates
Age-specific notification rates were calculated using population estimates obtained for age-specific mid-year estimated resident population data for calendar years 2005–2015 available from the ABS (Catalogue 3101.0, Table 58, published 17/12/2015).\(^3\) Indigenous status was not recorded in all datasets, therefore only whole of population rates were generated.

Data analysis
Data cleaning and analysis was completed in Stata IC v14 (StataCorp LP, College Station, TX, USA) and Microsoft Excel (Microsoft, USA) was used to generate tables and figures. As the interest was to examine only incident notifications and tests, duplicate notifications were excluded. Multiple tests reported within one maximum incubation period (4 days) for the same record were also excluded. These were likely to be repeat testing or clinical confirmation rather than onset of new illness. Influenza notifications or tests where the recorded postcode indicated residence outside of the ACT were also excluded from analysis. Date of specimen collection was featured in all datasets, whereas date of onset was available for notifications only. Date of specimen collection was then used to define the period of analysis.

Descriptive analysis
Data were analysed for the time period available in each respective data set. For test data, the proportion of positive tests were calculated as a percentage. Data were analysed by five-year age groups for those aged 0–19 years, ten-year age groups for those aged 20–79 years, and by those aged greater than 80 years. Only serology and PCR tests were provided in the laboratory datasets. Where PCR and serology was requested both results were included in analysis.

Test for trend was conducted using Pearson’s correlation coefficient using the nptrend command in Stata IC v14, and Pearson’s chi-square test used to measure association between covariates. A \(P\) value of less than 0.05 was considered statistically significant.
Chapter 2

**Regression modelling**

To investigate the relationships between both notification and positive tests for influenza and covariates: sex, age, year, diagnostic method and testing laboratory, regression modelling was undertaken. The data were first fit to a Poisson model. A chi-squared goodness of fit test was performed to test the appropriateness of the Poisson model. If the $P$ value was <0.05 the data was not considered to fit the model. Data were also graphed against Poisson and negative binomial probabilities using the Stata command `nbvargr`, to observe which model had the best fit. Where the negative binomial model appeared to have the best fit, this model was used.

Negative binomial regression models were used to estimate incidence rate ratios (IRR) of notifications and positive tests adjusting for sex, age, year, diagnostic method and testing laboratory. A Wald test was performed on all covariates in the model. Covariates were considered significant predictors of influenza notifications or positive tests in the model if the $P$ value was <0.05. The date of specimen collection was used to do determine the year of notification and test. Age and sex specific estimated resident population were used as denominator to standardise notifications to the population tested in the notification model; and the total number of tests performed by the two providers was used as a denominator to standardise positive tests to the population tested.

**Sensitivity analysis**

The 2009 influenza A/H1N1pdm09 pandemic saw an unprecedented number of influenza tests in the ACT. Sensitivity analysis was carried out to examine the impact of 2009 testing practices on the positive test model results. Positive test data with specimen collection dates in 2009 were excluded and regression analysis was conducted using the same methodology outlined above (Supplementary table 1).
Results

There were 5,820 notifications for influenza reported to the NDMS with a specimen collection date between 2005 and 2015. Over this period the rate of influenza notifications increased significantly ($P<0.05$). Between 2005 and 2012 there were 17,268 tests conducted overall. During this period (2005–2012) a significant increase in tests was only observed if 2009 was removed from the analysis ($P<0.05$). Including all available test data a significant increase in testing was observed during the 2005-2015 period ($P<0.05$) (Figure 1). Moreover, at Laboratory A, during 2013–2015, 7,982 tests were conducted which represented 45.4% of overall tests conducted by Laboratory A (Figure 1. box).

![Influenza notification and test rates (per 100,000 population) and proportion of positive tests (%), ACT, 2005–2015, by year](image)

Table 1 shows test counts and the percent of positive tests by year. The overall proportion of positive tests during 2005–2012 was 17.5% (3026/17268; annual range 8.9%–21.4%). No trend in test positivity over time was observed ($P>0.05$) (Figure 1). During 2013–2015 the proportion of positive tests from Laboratory A was 14.9% (1193/7982; annual range 11.4–18.5%) (Table 1).
Table 1: Influenza test count by negative, positive and total tests, and the percent of positive tests by year, ACT, 2005-2015

<table>
<thead>
<tr>
<th>year</th>
<th>negative tests*</th>
<th>positive tests*</th>
<th>total number of tests*</th>
<th>percent of positive tests (%)</th>
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<tr>
<td>2005</td>
<td>246</td>
<td>33</td>
<td>279</td>
<td>11.8</td>
</tr>
<tr>
<td>2006</td>
<td>566</td>
<td>82</td>
<td>648</td>
<td>12.7</td>
</tr>
<tr>
<td>2007</td>
<td>1543</td>
<td>353</td>
<td>1896</td>
<td>18.6</td>
</tr>
<tr>
<td>2008</td>
<td>1537</td>
<td>241</td>
<td>1778</td>
<td>13.6</td>
</tr>
<tr>
<td>2009</td>
<td>5226</td>
<td>1353</td>
<td>6579</td>
<td>20.6</td>
</tr>
<tr>
<td>2010</td>
<td>1564</td>
<td>151</td>
<td>1715</td>
<td>8.9</td>
</tr>
<tr>
<td>2011</td>
<td>1774</td>
<td>294</td>
<td>2068</td>
<td>14.2</td>
</tr>
<tr>
<td>2012</td>
<td>2455</td>
<td>654</td>
<td>3109</td>
<td>21.0</td>
</tr>
<tr>
<td>2013 †</td>
<td>2079</td>
<td>260</td>
<td>2339</td>
<td>11.1</td>
</tr>
<tr>
<td>2014 †</td>
<td>2324</td>
<td>518</td>
<td>2842</td>
<td>18.2</td>
</tr>
<tr>
<td>2015 †</td>
<td>2896</td>
<td>480</td>
<td>3376</td>
<td>14.2</td>
</tr>
</tbody>
</table>

* reports all influenza test methods used by the two reporting laboratories including: culture, serology nucleic acid testing (PCR) only
† testing data reported for Laboratory A only

Females represented 53% (3083/5820) of notifications, 52% (8931/17323) of tests, and 53% (1607/3011) of positive tests. The distribution of notifications or positive tests by sex did not differ significantly between testing laboratory (P>0.05). The proportion of tests conducted for females at Laboratory B however, was significantly higher compared to Laboratory A (P<0.05) (Table 2).

Table 2: Influenza notifications, test and positive test counts and proportions by pathology laboratory and sex, ACT, 2005–2015

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>notifications†</th>
<th>tests</th>
<th>positive tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>N(%)</td>
<td>N(%)</td>
</tr>
<tr>
<td>Laboratory A*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1241 (53%)</td>
<td>8896 (51%)</td>
<td>1382 (53%)</td>
</tr>
<tr>
<td>Male</td>
<td>1081 (47%)</td>
<td>8660 (49%)</td>
<td>1242 (47%)</td>
</tr>
<tr>
<td>Laboratory B**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1402 (53%)</td>
<td>4170 (55%)</td>
<td>857 (54%)</td>
</tr>
<tr>
<td>Male</td>
<td>1226 (47%)</td>
<td>3477 (45%)</td>
<td>720 (46%)</td>
</tr>
</tbody>
</table>

† notification data from 2005–2015
* test data for Laboratory A from 2005–2015
** test data for Laboratory B from 2015–2012

The age distribution of notification rates peaked in the young and elderly. Comparatively the age distribution of notification counts peaked in adults aged between 20 and 69 years. This likely reflects the population dynamics of the ACT and that the young and elderly are at increased risk of illness. (Figure 2). In notification and test data there was a significant association between age group and testing laboratory (P<0.05) with the proportion of
notifications and tests conducted in children aged 0–4 years and the elderly aged ≥80 higher at Laboratory A compared to Laboratory B (Table 3). The median age at specimen collection of notified influenza cases for the period 2005–2015 was 32 years (range 0–101 years). Influenza notification rates peaked at 0–4 years of age and ≥80 years of age, concordant to increases in the IRR of notifications for those aged 0–4 (IRR 2.26, \( P < 0.05 \)) and ≥80 (IRR 2.49, \( P < 0.05 \)) in the negative binomial regression model (Table 5).

Figure 2: Influenza age specific notification counts and rates per 100 000 population, ACT, 2005-2015

In test data the median age at specimen collection of individuals tested for influenza between 2005 and 2012 was 27 years (range 0–102 years), and 26 years (range 0–96 years) for individuals who returned positive test results. The age distribution of testing rates mirrored notifications, although the peak in the 0-4 year age group was more pronounced (Figure 3). In contrast to notification rates, test positivity peaked at 10–14 years, then declined inversely with age (Figure 3). The IRR of positive tests were lowest at 0–4 years (IRR 0.39, \( P < 0.05 \)) and at ≥60 years (Table 5).
Table 3: Notification and test count and proportion (%) by age group and proportion for positive tests by age group and testing laboratory, ACT, 2005–2015

<table>
<thead>
<tr>
<th>Age group</th>
<th>Notifications</th>
<th>Tests</th>
<th>Proportion positive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory A</td>
<td>Laboratory B</td>
<td>N (%)</td>
</tr>
<tr>
<td>0-4</td>
<td>374 (16%)</td>
<td>145 (6%)</td>
<td>6409 (36%)</td>
</tr>
<tr>
<td>5-9</td>
<td>196 (8%)</td>
<td>154 (6%)</td>
<td>883 (5%)</td>
</tr>
<tr>
<td>10-15</td>
<td>109 (5%)</td>
<td>130 (5%)</td>
<td>464 (3%)</td>
</tr>
<tr>
<td>15-19</td>
<td>157 (7%)</td>
<td>232 (9%)</td>
<td>652 (4%)</td>
</tr>
<tr>
<td>20-29</td>
<td>369 (16%)</td>
<td>430 (16%)</td>
<td>1599 (9%)</td>
</tr>
<tr>
<td>30-39</td>
<td>304 (13%)</td>
<td>450 (17%)</td>
<td>1586 (9%)</td>
</tr>
<tr>
<td>40-49</td>
<td>251 (11%)</td>
<td>356 (14%)</td>
<td>1452 (8%)</td>
</tr>
<tr>
<td>50-59</td>
<td>183 (8%)</td>
<td>302 (11%)</td>
<td>1390 (8%)</td>
</tr>
<tr>
<td>60-69</td>
<td>104 (4%)</td>
<td>213 (8%)</td>
<td>1147 (7%)</td>
</tr>
<tr>
<td>70-79</td>
<td>110 (5%)</td>
<td>116 (4%)</td>
<td>994 (6%)</td>
</tr>
<tr>
<td>≥80</td>
<td>165 (7%)</td>
<td>102 (4%)</td>
<td>1021 (6%)</td>
</tr>
</tbody>
</table>

*data available for 2005–2012
‡ Calculated using Pearson’s chi-square test
P value 0.00 equates to P <0.001
Figure 3: Influenza age specific test rates and the proportion of positive tests (%), ACT, 2005-2015

Notifications and tests from both testing laboratories demonstrated a seasonal trend, peaking during the winter and early spring months. Between 2005 and 2015, 87.1% of notifications reported a specimen collection date between weeks 22 and 41 (Figure 4). Similarly, during 2005–2012, 73.9% of tests reported a specimen collection data in weeks 21 to 41 (Figure 5), with 87.4% of positive tests occurring during these weeks. During 2013–2015, 61.4% of tests conducted at Laboratory A were conducted during weeks 21–41 (Figure 5), and 92% of those tests were positive.
Figure 4: Influenza notification counts, ACT, 2005-2015, by week and year
Figure 5: Influenza test counts, ACT, 2005-2015, by week and year
Between 2005 and 2015 the counts of notifications of PCR positive tests increased significantly ($P<0.05$) (Figure 6). The incidence of PCR notifications was significantly higher than other diagnostic methods (IRR 1.69, $P<0.05$) (Table 5). During time period 2005-2015 PCR accounted for 91% of notifications from Laboratory A, and 57.3% of notifications from Laboratory B (Table 4). Notifications for positive serology results came primarily from Laboratory B (Table 4), and increased significantly over the study period ($P<0.05$) accounting for 84.5% of total notifications for serology during the study period. There was no significant difference in test positivity rates between serology and PCR (Table 5). The IRR of positive tests was highest when PCR and serology were both requested/tested for an individual (IRR 1.47, $P<0.05$) (Table 5).

![Influenza notifications confirmed by PCR testing by laboratory, ACT, 2005-2015](image)

**Figure 6: Influenza notifications confirmed by PCR testing by laboratory, ACT, 2005-2015**

The rate of positive tests at either pathology laboratory did not significantly change over the study period. The incidence of notifications did not differ significantly between testing laboratory, while the incidence positive tests was higher at Laboratory B (1.52, 95% CI 1.35-1.71) relative to Laboratory A (Table 5). Sensitivity analysis was carried out to examine the influence of 2009 testing practices on the overall model results presented. Excluding the 2009 pandemic year from analysis there was no significant effect on age
Data analysis groups or diagnostic methods in the model. Significant changes to the analysis excluding 2009 were: the incidence rate ratio of positive tests became statistically significant and increased to 1.62 for the year in 2007. Moreover, the incidence rate ratio of positive tests for Laboratory B increased to 1.9 and remained statistically significant in the sensitivity analysis model (Supplementary table 1).

Table 4: Number and proportion (%) of notifications, tests and percent of positive tests by laboratory and diagnostic methods, ACT, 2005-2015

<table>
<thead>
<tr>
<th>Diagnostic method</th>
<th>Laboratory A</th>
<th>Laboratory B*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>notifications</td>
<td>tests</td>
</tr>
<tr>
<td>PCR</td>
<td>2122 (91%)</td>
<td>9433 (53.6%)</td>
</tr>
<tr>
<td>serology</td>
<td>65 (2.8%)</td>
<td>3136 (18.8%)</td>
</tr>
<tr>
<td>other</td>
<td>145 (6.2%)</td>
<td></td>
</tr>
<tr>
<td>PCR &amp; serology</td>
<td>4851 (27.6%)</td>
<td>14.6%</td>
</tr>
</tbody>
</table>

*test data available for 2005–2012 only
Table 5: Incidence rate ratios calculated using negative binomial regression of influenza notifications and positive tests by gender, age, year, diagnostic method, and testing laboratory, 2005–2015 (notifications), 2005–2012 (positive tests)

<table>
<thead>
<tr>
<th></th>
<th>Notifications*</th>
<th>Positive tests**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR*</td>
<td>P-value</td>
</tr>
<tr>
<td>sex (reference = female)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.92</td>
<td>0.12</td>
</tr>
<tr>
<td>Year (reference = 2005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1.28</td>
<td>0.38</td>
</tr>
<tr>
<td>2007</td>
<td>1.09</td>
<td>0.72</td>
</tr>
<tr>
<td>2008</td>
<td>1.70</td>
<td>0.02</td>
</tr>
<tr>
<td>2009</td>
<td>4.01</td>
<td>0.00</td>
</tr>
<tr>
<td>2010</td>
<td>0.65</td>
<td>0.09</td>
</tr>
<tr>
<td>2011</td>
<td>1.23</td>
<td>0.36</td>
</tr>
<tr>
<td>2012</td>
<td>2.31</td>
<td>0.00</td>
</tr>
<tr>
<td>2013</td>
<td>2.07</td>
<td>0.00</td>
</tr>
<tr>
<td>2014</td>
<td>4.40</td>
<td>0.00</td>
</tr>
<tr>
<td>2015</td>
<td>4.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Age groups (reference 20–29 years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4</td>
<td>2.26</td>
<td>0.00</td>
</tr>
<tr>
<td>5-9</td>
<td>1.53</td>
<td>0.00</td>
</tr>
<tr>
<td>10-14</td>
<td>1.00</td>
<td>0.97</td>
</tr>
<tr>
<td>15-19</td>
<td>1.38</td>
<td>0.00</td>
</tr>
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<td>30-39</td>
<td>1.02</td>
<td>0.85</td>
</tr>
<tr>
<td>40-49</td>
<td>0.95</td>
<td>0.63</td>
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<tr>
<td>50-59</td>
<td>0.95</td>
<td>0.60</td>
</tr>
<tr>
<td>60-69</td>
<td>0.95</td>
<td>0.65</td>
</tr>
<tr>
<td>70-79</td>
<td>1.34</td>
<td>0.03</td>
</tr>
<tr>
<td>≥80</td>
<td>2.49</td>
<td>0.00</td>
</tr>
<tr>
<td>Diagnostic test (reference notification = serology; reference test positivity = serology)</td>
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<td></td>
</tr>
<tr>
<td>PCR</td>
<td>1.69</td>
<td>0.00</td>
</tr>
<tr>
<td>Antigen detection</td>
<td>0.38</td>
<td>0.00</td>
</tr>
<tr>
<td>PCR &amp; serology</td>
<td>1.47</td>
<td>0.00</td>
</tr>
<tr>
<td>Testing laboratory (reference = Laboratory A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory B</td>
<td>0.98</td>
<td>0.81</td>
</tr>
<tr>
<td>Other laboratories</td>
<td>0.40</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*aIncidence rate ratio  
*bConfidence interval  
*offset by Population per 100,000 population  
**offset by number of tests per 1000 tests
Discussion

There has been a significant increase in the rate of influenza notifications in the ACT, during 2005–2015, most notably in the years following the 2009 pandemic (2010–2015). Nationally, increases in influenza notifications have been observed across similar time periods. The test rate in the ACT also appears to have increased, however without data available for all years from all laboratories, it is difficult to accurately ascertain the magnitude or significance of this increase. In contrast, the percentage of positive tests did not show any trend over time, despite variation between years. In 2009 and 2012 both positivity and testing rate peaked. This is consistent with a peaks in hospitalisations for influenza observation nationally during these years. The 2009 pandemic year also saw the notification incidence rate peak. In 2007, the positivity was also elevated, which is consistent with a peak in influenza death rates observed nationally in this year. The incidence of notifications did not express remarkable peaks in 2007 or 2012, despite peaks in positivity and evidence of more severe influenza outcomes. Whilst the apparent concordance between positivity and years with observed higher severe influenza outcomes observed in this analysis does not alone support an association. The findings highlight that notifications alone are likely unable to show the full epidemiological story of influenza in a given year.

Compulsory notification of confirmed influenza means notification data is biased by the number of tests conducted, making it difficult to estimate trends in true disease burden if increased testing occurs. The rise in notification rates in the ACT, in particular during 2013–2015, needs to be interpreted carefully as test rates during this time period also appear to have increased. Despite data only available from one laboratory for these years, the test rate was higher than all other non-pandemic years with the exception of 2012, where positivity peaked. The increased incidence rate of notifications for these periods may therefore reflect increased case ascertainment, rather than increased disease burden in the population. This finding is in keeping with reports from syndromic surveillance systems, which during the 2015 influenza season, reported slightly lower community ILI peaks in Flutracking and ASPREN surveillance data, compared to 2012 and 2014. Community ILI peaks in 2012 and 2014 reported by Flutracking, and ASPREN systems are consistent with peaks in the positive test rate we observed in the ACT. In this analysis, test data for the years 2013–2015 are reported by one laboratory only. This is the only laboratory that provides positivity data for influenza surveillance reporting in the ACT. As data for 2013–
2015, and seasonal surveillance reporting are currently available from only one laboratory, the possibility of selection bias makes it difficult to interpret positivity trends for these years where we have seen the largest increase with confidence.

Overall, the notification incidence rate was highest amongst 0-4 year olds and those age ≥80 years. Although notification counts were highest in those age 20–49 years, this most likely reflects the population distribution of the ACT, where the median age is 34.5 years at the last census year, 2011. The age group specific distribution of tests was similar to notifications, however the proportion of positive tests was lowest in these age groups and peaked in children aged 10–14. The higher proportion of positive tests observed in older children and young adults (5–29 years), in particular the 10–14 year age group, may suggest case ascertainment is low in these ages. Conversely, the low proportion of positive tests in the 0–4 year and ≥80 age groups may reflect high case ascertainment in these age groups and a high willingness to test by clinicians.

High testing frequency may be partly related to outbreaks of non-influenza respiratory infection which are also particularly prevalent in the young and the elderly. High prevalence of non-influenza respiratory illness would therefore drive increased testing and lower positivity, attributing to trends observed in the ACT test data. The collection of samples for PCR assays that detect multiple respiratory pathogens for ILI presentations in these age groups for example has recently been proposed to explain similar epidemiologic phenomena in a review of national hospitalisation data. It has also been suggested however, that for this effect to have an effect on the interpretation of notification trends, such bias would need to be continual, strong and neglected in analysis to pose the same threat of misinterpretation as not considering the proportion of positive tests.

Both ACT-based pathology laboratories offer specimens be submitted for a respiratory virus panel of assays for their PCR testing. The proportion of positive tests conducted for children and the elderly, and the proportion of tests for PCR were both greater at Laboratory A. This may reflect that Laboratory A is the only provider that serves the public hospitals in the ACT. Here we hypothesize that hospitals are more likely visited by high risk age groups (young and elderly) and the use of PCR panel testing hospital settings may drive down positivity in the presence of other circulating respiratory viruses. Future research of case admission data would provide valuable insight into the effect non-notifiable, non-influenza circulating respiratory illness has on test positivity for influenza and assist in understanding
Data analysis

positivity trends. In addition, there were also significant differences between the two laboratories by sex, with a significantly greater proportion of both tests conducted for females at Laboratory B. The differences in distribution of age and sex between the two laboratories analysed, suggests that selection bias may influence the generalisation of positivity trends in reporting.

PCR was added to the Medicare Benefit Schedule (MBS) in 2005, and funding for PCR was boosted following the 2009 pandemic. In Australia has been previously attributed to increased accessibility to, and frequency of, PCR testing. In the ACT, the use of PCR testing has increased significantly over time and has contributed to the predominant proportion of notifications for influenza in the ACT since 2009. Although the rate of PCR notifications was 1.6 times greater than serology notifications, this analysis found no statistically significant difference in the positivity between the two diagnostic methods, despite PCR as a diagnostic test having greater sensitivity and specificity. Further, despite a higher proportion of serology tests conducted at Laboratory B the incidence rate for positive tests at Laboratory B was also higher.

Serology notifications and testing results should be interpreted with caution. Previous comparisons of PCR and serology sensitivity and specificity in detecting influenza from ILI in the community setting identify serology as slow, insensitive and difficult to interpret, especially at low titres and out of season. Poor specificity of serology as a marker of recent influenza infection may report non-acute or recently recovered cases and mask the relative impact of PCR on test positivity. A recent study of general practice sentinel surveillance of ILI has demonstrated the proportion of patients with ILI correlated to influenza test positivity in primary care patients. Assuming that Laboratory B, being a private laboratory, primarily services general practice, a similar study in the ACT would be of benefit in answering some of the issues in surveillance and positive test interpretation identified above.

Limitations
The ACT notifiable disease surveillance system (NMDS) is unable to capture multiple tests records for cases i.e. only one diagnostic method can be recorded in the system. Common surveillance practice is to enter PCR if completed regardless of other test results. Comparing notification data with test data may therefore underestimate the number of other diagnostic methods also requested by treating clinicians. Between 2005–2012 positive results for requests that provided specimens for both PCR and serology testing were
responsible for 22.2% of all notifications. Overestimation in this analysis may be evident in the significantly higher IRR for PCR notifications, and lack of significantly higher IRR for PCR positive tests.

A number of pathology laboratories provide services to the ACT. Here we only consider test data from two of those laboratories which accounted for 85% of notifications during the study period, thus limiting the potential for selection bias. Data availability also limited our analysis of test data to the period 2005–2012. It is difficult to draw conclusions to help interpret notifications for the period 2013–2015 using a single laboratory’s test positivity data, due to the particular testing features of that laboratory identified through this analysis.

Variation in seasonal influenza type and subtype has been shown to influence different at-risk populations, in particular age groups, and also the severity illness. As influenza type or subtype does not affect the sensitivity or specificity of diagnostic tests considered, we have not considered analysis by subtype here.

Conclusion
This analysis sought to examine trends in influenza using both notification and testing data. While notification rates have increased and test rates appear to have increased between 2005 and 2015, the proportion of positive tests does not confirm increasing influenza activity over time. The difference in the rate of positive tests observed between the two pathology laboratories considered in the analysis suggest selection bias may be underestimating the actual proportion of positive tests reported in the ACT. The findings from this analysis also indicate that testing behaviours and case demographics may vary between laboratories, and that consideration of potential bias in estimating test positivity is an important consideration when limited test data is available. The ACT would benefit from receiving negative test data from all pathology providers who service the ACT and incorporating this information into the existing notification system. Future research into the relationship between non-influenza respiratory illness and positivity would be of particular use for establishing surveillance thresholds for influenza, and an exploration of other surveillance methods to enhance influenza surveillance in the ACT are recommended.
Reference list


## Supplementary material

**Supplementary table 1: Incidence rate ratios calculated using negative binomial regression of influenza notifications and positive tests by gender, age, year, diagnostic method and testing laboratory, 2005 -2012 (positive tests)**

<table>
<thead>
<tr>
<th></th>
<th>Positive tests* Inclusive 2009</th>
<th></th>
<th>Positive tests* Exclusive 2009</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRRa</td>
<td>P**</td>
<td>95% CI</td>
<td>IRRb</td>
</tr>
<tr>
<td>Sex (reference = female)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.97</td>
</tr>
<tr>
<td>Year (reference = 2005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>2007</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>1.62</td>
</tr>
<tr>
<td>2008</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>1.15</td>
</tr>
<tr>
<td>2009</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
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<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
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<tr>
<td>2011</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>2012</td>
<td>0.99</td>
<td>0.79</td>
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<td>1.91</td>
</tr>
<tr>
<td>Age groups (reference 20-29 years)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0-4</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.41</td>
</tr>
<tr>
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<td>0.79</td>
<td>0.89–1.10</td>
<td>1.01</td>
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<tr>
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<td>0.99</td>
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<td>0.89–1.10</td>
<td>1.12</td>
</tr>
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<td>15-19</td>
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<td>0.79</td>
<td>0.89–1.10</td>
<td>0.81</td>
</tr>
<tr>
<td>30-39</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.82</td>
</tr>
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<td>40-49</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.67</td>
</tr>
<tr>
<td>50-59</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.74</td>
</tr>
<tr>
<td>60-69</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.61</td>
</tr>
<tr>
<td>70-79</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.55</td>
</tr>
<tr>
<td>≥80</td>
<td>0.99</td>
<td>0.79</td>
<td>0.89–1.10</td>
<td>0.64</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCR</td>
<td>1.02</td>
<td>0.81</td>
<td>0.89–1.16</td>
<td>0.86</td>
</tr>
<tr>
<td>PCR &amp; serology</td>
<td>1.47</td>
<td>0.00</td>
<td>1.26–1.73</td>
<td>1.44</td>
</tr>
<tr>
<td>Testing laboratory (reference = Laboratory A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory B</td>
<td>1.52</td>
<td>0.00</td>
<td>1.35–1.71</td>
<td>1.90</td>
</tr>
</tbody>
</table>

aIncidence rate ratio  
bConfidence interval  
*offset by number of tests per 1000 tests  
**P<0.001 reported as P=0.00
Chapter 3

Exploring the relationship between heat and enteric infection in the Australian Capital Territory using different temperature metrics
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Prologue

Role

The undeniable warming of the climate system has seen rising atmospheric and ocean temperatures, diminished snow and ice and rising sea levels, with predicted increased frequency of extreme climatic events such as heatwaves, floods, droughts and cyclones. Rising temperatures and increased heatwave frequency are likely to become an increasingly pertinent public health concern in Australia.

The ACT Extreme Heat Plan (EHP) 2014 is intended to be a health protection tool to guide the whole of government response to extreme heat conditions. In light of new research into heatwave definitions and health impact the Office of the Chief Health Officer (OCHO) was interested in studying the relationship between heat and human health in the ACT.

Originally my role was to design and implement a study focusing on morbidity and heat using hospitalisation data. Unfortunately, this was unable to be completed during my placement due to issues surrounding obtaining relevant data. In lieu of studying the relationship between heat and morbidity, and following consultation with my academic and workplace supervisors, I redesigned the project to instead look at the relationship between heat and the incidence of notifiable enteric infections, namely Salmonella spp, Campylobacter spp, and Cryptosporidium. This decision was made with two thoughts in mind. Firstly, notification data was accessible, and secondly although a seasonal pattern of increased notification incidence during summer months was acknowledged, the relationship between heat and enteric illness had not been previously studied in the ACT.

Lessons learnt

The biggest lesson I learnt during this project was with regards to project management. The primary research aim of the project was to allow for evidence-based policy review, however, due to data accessibility issues, I was unable to undertake the original project. Resultantly, I had to adapt the project to make use of available data which would still be useful to ACT Health, and did so by shifting the focus of the project to a more methodological scope. By comparing different measures of heat, we were still able to provide findings that will hopefully be useful to ACT Health for future studies, in addition to the findings of the study itself.
I learnt how to extract data from a publically available meteorological data source and how to format that data for a time series analysis. The steps involved in extracting, formatting and then using these data for descriptive analysis formed the basis for my lessons from the field exercise.

Finally, the project taught me how to undertake a time series analysis including complex modelling techniques. I was introduced and learnt how to use R, and in particular, learnt how to download packages and prepare data sets to run models.

**Implications for public health**

This study has implications for the development of future study design with regards to the indices used to examine the associations between weather and disease. While simple temperature statistics such as averaged mean or maximum temperatures by day, week or month continue to be used, the present study shows more complex indices of heat may be useful as they are able account for the acclimatisation of biological systems to periods of increased heat. For example, whilst some enteric disease incidence increase in summer months may be due to changes in eating behaviours; ambient temperature also contributes to pathogen amplification in the environment, thus increasing potential for contamination and subsequently human infection.\(^2,3\) The findings from the present study will be able to form more direct public health messaging around food preparation and safety in the ACT.

**Acknowledgments**

In acknowledging the following people for their involvement in the project, I also thank them for their support, guidance, and motivation as keen public health practitioners seeking to improve the community’s quality of health.

My academic supervisor Dr Aparna Lal whose expertise in modelling infectious disease and climate variables was invaluable and whose constant support, guidance and mentorship I am extremely grateful for.

My workplace supervisors, Ms Rebecca Hundy and Dr Marlena Kaczmarek, for their guidance, assistance and patience throughout the project.
All the staff from the Communicable Disease Control Section at ACT Health, Sue Reid, Rachel Crane, Milica Stefanovic, Michelle Boxx, Jodie Huet, Carolyn Banks, Ashleigh Keeling, Miranda Harris, Sam Kelly, Romaine Huggett and Sandy Wynn.

Officer of the Chief Health Officer public health physicians Dr Andrew Pengilley and Dr Vanessa Johnston for their guidance in the development of and amendments to the project and their support to do so.

Craig Cannon from the Health Emergency Management Unit (HEMU) at ACT Health for his technical support.

**Master of Philosophy (Applied Epidemiology) core requirement**

This chapter is included in my bound volume to fulfil the Master of Philosophy (Applied Epidemiology) requirement of: design and conduct an epidemiological study and submission of an advanced draft of a paper for submission.
Exploring the relationship between heat and enteric infection in the Australian Capital Territory using different temperature metrics

Submitted as an advanced draft for publication

Abstract

Background

Rising average and peak temperatures, are expected to impact the risk of food and waterborne disease amongst populations. Evidence for the association between temperature and enteric illness is reported, however many studies use simple measures if temperature such as maximum (ºC) or daily mean temperatures (DMT). We present a comparison of the use of these variables with the use of an excess heat index for acclimatisation (EHI_{accl}) – a rolling function of temperature that accounts for short term temperature differences in relation to the recent past – to assess the association between heat and three common enteric pathogens in the Australia Capital Territory.

Methods

Notification data of campylobacteriosis, salmonellosis and cryptosporidiosis cases were extracted from the ACT notifiable disease management system for the period 2006–2016, where available. Temperature variables were calculated from freely available daily meteorological data made available by the Australian Bureau of Meteorology for the same time period from ACT weather stations with complete data. To demonstrate disease and temperature patterns descriptive time series was conducted and Spearman’s correlation was used to measure the association between variables. Generalized linear models with Poisson regression accounting for overdispersion were applied to estimate the associations of mean weekly temperature, maximum weekly temperature and EHI_{accl}.

Results

EHI_{accl} consistently modelled notifications of campylobacteriosis, salmonellosis and Cryptosporidiosis comparably to using maximum and mean temperatures as weather predictors of infection. Using EHI_{accl}, a small increased risk for reported salmonellosis was identified at the 50th percentile of the index, and at the 90th percentile versus the mean for a lag of up to 4 weeks. Cryptosporidiosis showed increased risk significant at the 50th and 90th
percentiles and had a significantly increased risk up to a 6 week lag at the 90th and between
1–3 weeks at the 50th percentile versus the mean. Increased risk was observed between
mean weekly maximum temperatures (°C) at the 50th percentile for both diseases. No
associations or significant increased risk lag periods were observed for campylobacteriosis
with any temperature metric.

Conclusion

We present a novel tool for investigating the relationship between heat and the incidence of
notified enteric infection. The heat stress index EHI_{accl} represents short-term temperature
anomalies compared to the recent past. Reported salmonellosis and cryptosporidiosis were
both positively associated with increased temperature anomalies in the short term. Our
findings build on previous work by understanding the short-term and delayed impact of
temperature on enteric illness in Australia.
Introduction

The irrefutable warming of the climate system has seen a rise in atmospheric and ocean temperatures, diminishing snow and ice and an increase in sea levels. As these trends are expected to continue into the 21st century, the link between human health and environmental factors, such as temperature and infection with pathogenic microorganisms, needs to be better understood. Rising frequency of extreme weather events, and rising average and peak temperatures, are expected to impact the risk of food and waterborne disease amongst populations. Foodborne bacterial pathogen replication and survival is dependent on environmental conditions, such as temperature, pH and water availability. Similarly, waterborne pathogen dispersal is affected either directly by meteorological events such as flooding, or indirectly by alterations to the distribution of animal reservoirs in response to changing climate. Additionally, enteric illness causing pathogens are spread by a variety of transmission pathways, and changing weather patterns are likely to affect the persistence and spread of such microorganisms. These include common foodborne and waterborne pathogens such as Salmonella spp, Campylobacter spp, and Cryptosporidium.

Enteric illness is a significant public health issue in Australia. It has been estimated that circa 2010 in Australia, there were 4.1 million cases of foodborne gastroenteritis, placing a substantial burden on individuals, the health care system, the economy and trade. Although most enteric illness is mild and self-limiting, some infections result in severe illness, hospitalisation and long term sequelae.

In temperate climates, foodborne and waterborne enteric infections typically follow seasonal patterns, alternating between periods of low endemic activity and periods of increased infection incidence and outbreak frequency. Increases in ambient temperature can affect the survival and replication of infectious microorganisms in the environment through increased microbial activity. Additionally, temperature modifies food preparation behaviours and preferences, as well as favoured recreational activities, such as swimming, resulting in increased exposure to both food and waterborne pathogens. The incidence of bacterial infection with Salmonella spp. and Campylobacter spp. typically rises during warmer summer months and declines during winter. Similarly, the incidence of infection with the protozoa Cryptosporidium, typically associated with contaminated water, also exhibits seasonal variation.
Salmonella spp. and Campylobacter spp. are temperature sensitive bacteria which infect humans primarily via direct transmission through the faecal-oral route or ingestion of contaminated food. Cryptosporidium is a protozoan parasite transmitted as infective oocytes also primarily via the faecal-oral route or by ingestion of contaminated food or water. The pathogen load in food or produce contaminated with Salmonella spp. and Campylobacter spp. can be affected by exposure to different temperatures. Similarly oocyte infectivity in water sources has been demonstrated to be subject to, among other environmental factors, temperature variation. Better understanding of the short term relationship between ambient temperature variation and incidence of infection is important to reduce disease burden.

Much of temperature and health research focuses on non-communicable morbidity outcomes. The effects of exposure to high ambient temperatures on the human body are well described, and the impact of elevated heat stress on populations are commonly modelled by epidemiologists. Typically associated are increases in incidence of respiratory and cardiovascular conditions, and renal conditions as well as direct heat related illness. A range of indices to quantify the impact of heat stress on human health are available to epidemiologists, however, modelling projections of health outcomes in general are sensitive to the temperature index used, and work comparing indices is nascent.

Although less frequently studied, evidence for association between temperature and enteric illness has been observed previously in Europe, the United Kingdom, the United States, Canada and Australia. Frequently, investigations have considered temperature measured as aggregated daily, weekly, or monthly maximums or 24-hour means. Excess heat indices (EHI) on the other hand are rolling functions of temperature that can capture temperature anomalies such as excess heat resulting from heat accumulation which does not dissipate overnight due to high minimum temperatures following a high heat day, and heat stress which reflect a short term temperature anomaly of a period of warmer than average temperatures, compared to the recent past. In this paper we present the use of the EHI acclimatisation index (EHI_{accl}), defined by Nairn and Fawcett (2013), as a function of heat stress, to investigate the short term association between heat and enteric infection. EHI_{accl} provides a relative measure of periods where the temperature is hotter on average compared to the recent past. Positive values are associated with relatively hot weather (excess heat), and negative values are
Chapter 3

associated with relatively cooler weather. In the face of global climate changes weather
predictors of disease incidence are likely to become an increasingly important public health
tool to mitigate increased health risk.

**Methods**

**Study site**
We used disease notification data for residents of the Australian Capital Territory (ACT) and
meteorological data captured by the Australian Bureau of Meteorology (BOM) from
weather stations within the territory. The ACT is largely suburban, with approximately
400,000 residents living in and around the central area of Canberra. It is situated at an
altitude of 574 metres above sea level and has an oceanic, temperate climate. On average,
Canberra suffers much colder winters compared to other Australia cities, despite having
summer temperatures that are consistent with the coastal capitals. Seasonal temperature
variation in Canberra is subsequently usually more dramatic compared to other Australian
cities.

**Enteric disease data**
All notified, de-identified laboratory confirmed cases of salmonellosis, campylobacteriosis
and cryptosporidiosis during the period 2006-2016 in the ACT were extracted from the
Notifiable Disease Management System operated by the ACT Health, Communicable
Disease Control Section (CDCS). During data collection of laboratory confirmed cases, if a
date of onset of illness is not identified, the date of specimen collection is entered into this
field in lieu which does not accurately reflect the case’s onset. To account for this, all cases
that had an identical date of onset and date of specimen collection were excluded. Based on
this method, zero cases were excluded for cryptosporidiosis (n=377), 4% of salmonellosis
(96/2188) and 35% (1834/5263) of campylobacteriosis cases were excluded. Where the
number of notifications excluded by this method exceeded 50% in a given year, that year
was excluded from analysis. Based on this, campylobacteriosis cases in the years 2013–
2016 were excluded.

Using onset date, cases were aggregated into counts by week over the study period. Annual
resident population estimates available from the Australian Bureau of Statistics (Catalogue
3101.0, Table 58, published 17/12/2015) were used as an offset in the analysis.
To prevent disease outbreaks biasing the analysis we created an indicator for an outbreak week to be a predictor variable in the final model. Using the definition for an outbreak month established by D’Souza et al: an outbreak week was defined as one with a weekly notification count greater than two standard deviations above the 11 year mean weekly count. This definition identified 14 outbreak weeks for cryptosporidiosis, 11 for campylobacteriosis and 10 for salmonellosis.

**Weather data**

For the time period 2006-2016, daily surface minimum and maximum temperatures (°C) and rainfall (millimetres) were obtained from the Bureau of Meteorology (BOM), Climate Data Online service. Daily values are measured for the 24 hours from 9.00am local time on the relevant day to 9.00am the following day. Only data from weather stations in the ACT where complete data was available over the study period were used. Daily mean maximum and minimum temperature (°C) were constructed from three weather stations and daily mean rainfall (mm) was constructed from 14 weather stations in the ACT. Daily data were aggregated by week to create weekly variables for maximum temperature (°C), mean temperature (°C) and rainfall (mm).

We compared three indices of heat: two simple, and one complex. The two simple were simple temperature statistics weekly maximum temperature (°C) and weekly mean temperature (°C). The complex index utilised was the heat stress index, EHI\textsubscript{accl}. EHI\textsubscript{accl} is expressed as a short-term three-day, daily mean temperature anomaly with respect to the recent past.\cite{50} To calculate \( EHI\textsubscript{accl} \) the formula is expressed:

\[
EHI\textsubscript{accl} = (T_i + T_{i+1} + T_{i+2})/3 - (T_i + ... + T_{i-30})/30, 
\]

Where \( T_i \) is the daily mean temperature (DMT) on the day \( i \) using degrees Celsius as the unit of measurement.\cite{50,52}

As we sought to identify the short term association between \( EHI\textsubscript{accl} \) as a function of cumulative temperature effects and enteric infection, to account for a heatwave exposures in our models, we created binary heatwave indicator variables attributed to a day clustered in three days of a maximum temperature set at a threshold of \( \geq35 \) °C.
**Data analysis**

**Descriptive**

To demonstrate disease patterns the weekly notification counts for each disease were plotted over the 11 year study period. The mean weekly maximum (°C) was also plotted over the time period to show trends in temperature variation. Summary statistics and Spearman’s correlation were used to determine the association between the weekly number of notifications for each disease and the weekly average of each heat metric. All descriptive data management and analysis was carried out in Stata IC v14 (StataCorp LP, College Station, TX, USA).

**Time-series model**

Generalized linear models with Poisson regression accounting for overdispersion were applied to estimate the associations of mean weekly temperature, maximum weekly temperature and EHI\textsubscript{accl} with campylobacteriosis from 2006–2012, and salmonellosis and cryptosporidiosis from 2006–2016 reported in the Australian Capital Territory.

Nonlinear and delayed associations with temperature were estimated through distributed lag nonlinear models (DLNMs). These models are able to describe complex nonlinear and lagged dependent relationships through a cross-basis function, which is obtained by the combination of two functions that define the conventional exposure-response relationship and the additional lag–response relationship, respectively.\textsuperscript{53} Here the cross-basis function is composed of a quadratic B-spline for the exposure–response with two internal knots placed at the 5\textsuperscript{th} and 90\textsuperscript{th} percentiles of temperature distributions, and a natural cubic B-spline for the lag–response with an intercept and two internal knots at equally spaced values in the log scale. To capture the delayed effects of heat, and to account for short-term harvesting, the lag period was extended to 10 weeks. These modelling choices were based on previous work.\textsuperscript{53, 54} The other terms in the model included mean weekly rainfall (mm) as a natural spline function with 4 degrees of freedom, disease counts lagged by one week, outbreak and heatwave weeks (as indicator variables) and a variable for long-term trend. Annual population estimates were included as an offset.

Time series analysis were performed using R software (version 3.1.1), with functions in the package ‘dlnm’.\textsuperscript{54} Cumulative associations were computed as the relative risks from the overall cumulative exposure-response relationships, representing the net associations over the whole lag period. The association with weekly mean and maximum temperature, and
\(EHI_{\text{accl}}\) was also summarized as overall cumulative contributions for heat and cold at the 90\textsuperscript{th} and 5\textsuperscript{th} temperature and \(EHI_{\text{accl}}\) percentiles, respectively, using the mean value for the temperature and \(EHI_{\text{accl}}\) index range as the reference.

**Results**

A degree of seasonal variation is observed in the rate of notifications for all three diseases under investigation and temperature (Figure 1–3). The greatest proportion of cases were reported during the summer months for all diseases. Winter accounted for the fewest. Summer months were also responsible for the highest mean rainfall in the ACT during 2006–2016 and the highest mean temperature (Supplementary material Figures 1–3). The weekly maximum number of notifications varied by disease. The largest number of notifications reported was in 2010 (n=550). The mean weekly number of notifications was highest for campylobacteriosis, and lowest for cryptosporidiosis (Table 1). The minimum notifications reported in a week was zero for all three diseases. A slightly greater number of outbreak weeks was observed for cryptosporidiosis, compared to salmonellosis and campylobacteriosis (Table 1). Between 2006–2016 on average the weekly 24-hour mean temperature in the ACT was 13.9 °C, with a maximum weekly mean observed of 34.2°C. The weekly mean precipitation was 21.11 mm and the weekly mean heat stress index (\(EHI_{\text{accl}}\)) ranged from -5.85 to 7.35. (Table 1)

Correlations between weekly average maximum and 24-hr mean temperatures were statistically significant at \(P< 0.05\) (Supplementary material Table 1). Correlations between the different disease variables and \(EHI_{\text{accl}}\) were neither strong (cryptosporidiosis) or statistically significant (campylobacteriosis, salmonellosis) (Supplementary material Table 1). There were weak, but statistically significant correlation between mean weekly reported salmonellosis, campylobacteriosis and cryptosporidiosis. (Supplementary material Table 1) and there was no significant relationship observed between any disease and rainfall. Correlations between \(EHI_{\text{accl}}\) and other independent variables indicate relationships that were statistically significant but weak (Supplementary material Table 1)
Figure 1: Weekly salmonellosis notification rate per 100 000 population and weekly mean of daily temperature maximums (°C), ACT, 2006-2016

Figure 2: Weekly cryptosporidiosis notification rate per 100 000 population and weekly mean of daily temperature maximums (°C), ACT, 2006-2016
Figure 3: Weekly campylobacteriosis notification rate per 100 000 population and weekly mean of daily temperature maximums (°C), ACT, 2006-2016
### Table 1: Descriptive statistics for disease and climate variables, by week, ACT, 2006-2016

<table>
<thead>
<tr>
<th>Variable</th>
<th>24-hr mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>SD</th>
<th>Outbreaks weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter* (n)</td>
<td>8.76</td>
<td>0</td>
<td>23</td>
<td>3.89</td>
<td>11</td>
</tr>
<tr>
<td>Salmonella spp. (n)</td>
<td>3.66</td>
<td>0</td>
<td>70</td>
<td>4.36</td>
<td>10</td>
</tr>
<tr>
<td>Cryptosporidiosis (n)</td>
<td>0.66</td>
<td>0</td>
<td>13</td>
<td>1.47</td>
<td>14</td>
</tr>
<tr>
<td>Rainfall (mm)</td>
<td>1.94</td>
<td>0</td>
<td>21.11</td>
<td>2.90</td>
<td>-</td>
</tr>
<tr>
<td>24 hr mean temperature (°C)</td>
<td>13.9</td>
<td>3.2</td>
<td>26.3</td>
<td>5.77</td>
<td>-</td>
</tr>
<tr>
<td>Maximum temperature (°C)</td>
<td>20.8</td>
<td>10.0</td>
<td>34.2</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>Heat stress (EHI&lt;sub&gt;accl&lt;/sub&gt;)</td>
<td>0.46</td>
<td>-5.85</td>
<td>7.35</td>
<td>2.27</td>
<td></td>
</tr>
</tbody>
</table>

*Campylobacter data for 2006–2012

### Table 2: Estimated Relative Risk of reported enteric disease associated with 24 hr Mean and Maximum mean weekly Temperature and EHI<sub>accl</sub> variation in the Australian Capital Territory, 2006-2016

<table>
<thead>
<tr>
<th></th>
<th>Campylobacteriosis*</th>
<th>Salmonellosis</th>
<th>Cryptosporidiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RR</td>
<td>95%CI</td>
<td>RR</td>
</tr>
<tr>
<td><strong>Weekly 24 hr mean temperature (°C)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt; percentile (6°C)</td>
<td>0.38</td>
<td>0.13–1.12</td>
<td>0.36</td>
</tr>
<tr>
<td>95&lt;sup&gt;th&lt;/sup&gt; percentile (21.5°C)</td>
<td>1.49</td>
<td>0.53–4.17</td>
<td>1.43</td>
</tr>
<tr>
<td>EHI&lt;sub&gt;accl&lt;/sub&gt; (value)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; percentile (-3.2)</td>
<td>0.558</td>
<td>0.24–1.27</td>
<td>1.01</td>
</tr>
<tr>
<td>95&lt;sup&gt;th&lt;/sup&gt; percentile (3.2)</td>
<td>1.38</td>
<td>0.60–3.19</td>
<td>1.22</td>
</tr>
<tr>
<td><strong>Weekly maximum temperature (°C)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt; percentile (11.5°C)</td>
<td>0.95</td>
<td>0.51–1.79</td>
<td>0.26</td>
</tr>
<tr>
<td>95&lt;sup&gt;th&lt;/sup&gt; percentile (29°C)</td>
<td>1.12</td>
<td>0.66–1.91</td>
<td>1.42</td>
</tr>
</tbody>
</table>

*Campylobacter data for 2006–2012
Table 2 includes a summary of the estimated associations of disease with weekly 24 hour mean and maximum temperatures and EHI\textsubscript{accl} at the 5\textsuperscript{th}, 50\textsuperscript{th} and 90\textsuperscript{th} percentiles. Weekly maximum temperature was associated with a small increase in the risk of reported enteric disease, with relative risks of 1.05 (95% CI 0.99–1.05) for cryptosporidiosis and 1.03 (95% CI: 1.00–1.08) for salmonellosis, reported at the 50\textsuperscript{th} percentile. In contrast, inconsistent and insignificant associations were found for weekly 24 hour mean temperature and all diseases. EHI\textsubscript{accl} was overall positively associated with reported salmonellosis and cryptosporidiosis at all percentiles, although significance was not observed at all percentiles. For cryptosporidiosis, a relative risk of 5.02 (95% CI: 1.00–25.31) and 12.81 (95% CI: 2.97–55.27) was observed at the 5\textsuperscript{th} and 90\textsuperscript{th} percentile, respectively, and 1.04 (95% CI 0.99–1.10) at the 50\textsuperscript{th} percentile. For salmonellosis, EHI\textsubscript{accl} was positively associated with estimated relative risk of 1.02 (95% CI 1.00, 1.05) reported at the 50\textsuperscript{th} percentile. There were no statistically significant associations for campylobacteriosis with EHI\textsubscript{accl}.

The predictor-specific lag–response curves at the 5th and 90th temperature and EHI\textsubscript{accl} percentile, computed versus the mean values for each temperature measure, are represented in Figure 4–6. The weekly 24 hour mean temperature showed no significant relationship for any of the enteric diseases at any lag at the 5th (6°C) or 90th (21.5°C) percentile of the 24 hour mean temperature range. The graphs (Figure 4–6) are consistent with the lack of statistical significance shown for the overall association between 24 hour mean temperature and reported enteric disease in the ACT (Table 2). EHI\textsubscript{accl} at the 90th percentile (3.2) was positively and significantly associated with reported salmonellosis and cryptosporidiosis risk, with most risk limited to the first four weeks (lag 0–4) for salmonellosis, and significantly for up to the first six weeks (lag 0–6) for cryptosporidiosis. Cryptosporidiosis risk was also positively associated with the 5th percentile of the EHI\textsubscript{accl} (-3.2) in the first 2 weeks. For weekly maximum temperature, there was no relationship with the 5th percentile of temperature range (11.5°C) with any disease, but cryptosporidiosis showed a significant decrease in risk from 3-7 weeks, reported at the 90th percentile (29°C).
Figure 4: Estimated lag–response (lag) relationships in weeks between heat and reported campylobacteriosis, with 95% CIs. These curves are computed for the temperature corresponding to the 5th and 90th percentile vs. the average weekly temperature (A, B: top, right to left); 5th and 90th percentile vs. the average weekly $EHI_{accl}$ (heat-stress) (C,D: middle right to left); 5th and 90th percentile vs. the maximum weekly temperature (E,F: bottom right to left).
Figure 5: Estimated lag–response (lag) relationships in weeks between heat and reported salmonellosis, with 95% CIs. These curves are computed for the temperature corresponding to the 5th and 90th percentile vs. the average weekly temperature (A, B: to right to left); 5th and 90th percentile vs. the average weekly $EHI_{accl}$ (heat-stress) (C, D: middle right to left); 5th and 90th percentile vs. the maximum weekly temperature (E, F: bottom right to left).
Figure 6: Estimated lag–response (lag) relationships in weeks between heat and reported cryptosporidiosis, with 95% CIs. These curves are computed for the temperature corresponding to the 5th and 90th percentile vs. the average weekly temperature (A, B: top right to left); 5th and 90th percentile vs. the average weekly EHI_{accl} (heatstress) (C,D: middle right to left); 5th and 90th percentile vs. the maximum weekly temperature (E,F: bottom right to left).
Discussion

These findings suggest that in the ACT, short-term heat variability measured with respect to recent warmer temperatures is associated with enteric disease incidence. This study has shown that short-term anomalies in temperature relative to the previous 30 days can be a significant predictor of reported salmonellosis and cryptosporidiosis but not campylobacteriosis.

Reported salmonellosis and cryptosporidiosis cases in the ACT were positively and significantly associated with excess heat stress ($EHI_{acc}$). Slightly increased risk for salmonellosis was identified at the 50th percentile, and at the 90th percentile versus the mean for a lag of up to 4 weeks for salmonellosis. Cryptosporidiosis showed increased risk significant at both the 5th and 90th percentile with a significant lag up to 6 weeks at the 90th and between 1–3 weeks at the 5th computed versus the mean. This association was consistent with increased risk observed between mean weekly maximum temperatures ($^\circ$C) at the 50th percentile for both diseases. We did not observe an association between temperature and reported campylobacteriosis in any measures of heat considered in our analysis. $EHI_{acc}$ consistently modelled notifications of Campylobacter spp., Salmonella and Cryptosporidium infection comparably to using maximum temperatures as weather predictors of infection. Simple temperature statistics such as mean and maximum temperature are commonly used as heat indices for enteric infection in past research.\textsuperscript{13, 19, 21-23, 44} The use of temperature indices that capture the effects of recent weather conditions may prove more beneficial when compared with simple temperature statistics in the face of changing climates and possible subsequent changes to pathogen persistence, survival and growth.

To our knowledge our findings present the first evidence of increased salmonellosis incidence risk associated with short-term temperature anomalies, with respect to the previous 30-day mean temperature and is consistent with dominant peaks in notification incidence observed during the summer periods in the ACT. This result is consistent with previous research in Australia\textsuperscript{15, 22, 44} and globally\textsuperscript{2, 47, 48} where aggregated maximum or mean temperatures are utilised as independent variables. Seasonality is a well-established phenomenon in the epidemiology of reported enteric illness, with incidence increasing in warmer periods.\textsuperscript{15} Salmonella are motile, thermophilic anaerobic bacteria that, for the majority of sub-species exhibit optimal growth at $37^\circ$C.\textsuperscript{3, 5} Exposure to higher ambient
temperatures may increase the opportunity for pathogen amplification at multiple points along potential transmission pathways.\textsuperscript{55} For example, inadequate refrigeration of food or unsafe preparation,\textsuperscript{48, 56} untreated water sources\textsuperscript{57} or contaminated environments.\textsuperscript{5}

Foodborne transmission is the dominant source of *Salmonella* infection in many countries, including Australia.\textsuperscript{58-60} At the primary production level of the foodborne transmission pathway for *Salmonella* spp., exposure to warmer temperatures enhance the opportunity for pathogen multiplication and contamination of primary produce.\textsuperscript{61, 62} Inadequate refrigeration or food safety during production, distribution or storage during warmer temperatures is also likely to increase the risk of foodborne *Salmonella* spp. transmission.\textsuperscript{63} Increased risk of contamination at these ends of foodborne illness transmission pathway may reflect the temporal lag between weather variation and increased reported disease incidence (notifications).\textsuperscript{44} Previous studies have reported significant association between heat and a delayed notification incidence increases up to four weeks lag.\textsuperscript{44, 64-66} We also found a significant and positive lagged association between EHI\textsubscript{accl} and salmonellosis at the 90th EHI\textsubscript{accl} percentile computed, versus the mean value. In addition to past research our findings suggest the lagged association is present in relation to preceding heat conditions i.e. a week of relatively higher temperatures above the preceded 30-day mean.

The types of foods prepared and food preparation behaviours is likely to vary seasonally.\textsuperscript{16} An assessment of the role of poultry in driving salmonellosis seasonality in the U.K. concluded that despite evidence supporting chicken as a primary vehicle of salmonellosis to humans, retail chicken contamination did not drive disease seasonality.\textsuperscript{67} Rather exposures to other activities, namely barbeques (common in Australia) and gardening in the week prior to onset during warmer months were associated with infection.\textsuperscript{67} Such exposures may explain the short-term association identified here between increased risk of salmonellosis and temperature.

Since 1910, Australia has warmed ~ 1.0 °C.\textsuperscript{68} The shift to a warmer climate in Australia has been accompanied by increased frequency of extreme heat events on daily, multi-day and seasonal timescales.\textsuperscript{68} Increasing temperature could favour higher *Salmonella* spp. loads in the environment and at the same time preference social habits, such as outdoor activities and eating outside the home, potentially enhancing transmission opportunities.\textsuperscript{2, 5, 19} D’Souza et al, found an effect size of an approximate 5% increase in notifications per degree increase in the mean temperature of the previous month in Australian cities with
temperate climates. Results of the present study are in keeping with previous findings, and suggest the link between increased temperatures and *Salmonella* notification remains when accounting for acclimatisation to higher temperatures over a 30-day period.

Rising ambient temperature is therefore likely to impact the social and economic burden from *Salmonella spp.* infection in the future. Previous research has modelled the impact of climate change on the proportion of gastroenteritis cases of bacterial origin, providing an upper approximation which “estimate[s] for 2050 [a] rise to 335,000 new cases, over $92.3 million dollars in health and surveillance costs and 1.6 million lost workdays”. Or, at a lower estimate, “205,000 new cases, $56.5 million and 570,000 lost workdays”. Similarly, between Years Lost due to Disability (YLDs) for *Salmonella* infection in Australia in 2000 and estimates for 2030 and 2050 (accounting for increases in temperature and demographic changes), a 9%–48% increase in cases and a 31%–87% increase in YLDs for *Salmonella* infection has been estimated.

For cryptosporidiosis, weekly average EHI	extsubscript{accl} at the 90\textsuperscript{th} percentile was positively associated with weekly incidence. The percentile computed versus the mean also showed a significant positive association to a lag of six weeks. Positive association between cryptosporidiosis incidence and temperature of the previous month has been reported previously in Australia, and elsewhere. We observed increased risk of incidence peak at a lag of 10–14 days, which fits the upper limits of the incubation period for cryptosporidiosis (1–12 days). Considering the primary transmission mode for *Cryptosporidium* is through exposure to contaminated water sources, this lag may be driven by increased recreational water activities and other outdoor activities associated with warmer weather.

We also report a summer peak in cryptosporidiosis notification incidence in concordance with increased risk at the 90\textsuperscript{th} percentile in our EHI	extsubscript{accl} model. Seasonal peaks for cryptosporidiosis during (late) summer have been reported previously in the US, and other Australian studies. However, New Zealand, Europe, and the U.K. and Wales display two peaks of cryptosporidiosis incidence, one in spring, thought to be associated to agricultural processes such as the birth of livestock, and one in early autumn, linked to increased recreational water use and outdoor activities usually in warmer weather leading to increased person-to-person spread. The predicted higher risk at lag up to six weeks in our EHI	extsubscript{accl} model are likely in keeping with the increased incidence in early autumn observed in these countries. The ACT population is largely urban despite its rural
geographic location and is unlikely to be impacted by agricultural practices such as livestock birthing.

The pathways through which weather may affect transmission risks of cryptosporidiosis are complex. A systematic literature review considering the relationship between waterborne infection and temperature and precipitation identified findings from multiple studies to be heterogeneous, highlighting the complex relationship between either precipitation or temperature driven transmission of predominately waterborne infections. In Australia, a positive association with temperature has been previously reported in studies where either no relationship, or a negative relationship, between cryptosporidiosis incidence and weekly rainfall and relative humidity is observed, suggesting dry periods combined with high temperatures may affect transmission. However, outbreaks associated with increased precipitation have also been reported. In the ACT rainfall typically peaks during late spring and summer Adjusting for rainfall in our models, a positive association between weekly cryptosporidiosis and temperature (EHI_{acc} at the 90th percentile) remained.

The EHI_{acc} model also showed an increased relative risk of weekly cryptosporidiosis incidence with EHI_{acc} at the 5th percentile. As EHI_{acc} is essentially an anomaly of three-day daily mean temperature with respect to the previous three days, low EHI_{acc} represents periods of cooler than previously average temperatures. We do not present a substantive explanation for this association. The authors hypothesise the association may be drawn from fluctuation in human behaviour such as increased indoor swimming activity during cooler months. Swimming pools have been frequently associated with illness, and outbreaks of cryptosporidiosis associated with indoor swimming in pools have been reported in Australia previously, albeit during summer months. Further exploration on the interaction between season variation of recreational behaviours and enteric disease would provide useful information to guide public health messaging and action.

The lack of association between campylobacteriosis and either of the heat variable models is consistent with the literature which shows mixed findings. The association between increased ambient temperature and likelihood of Campylobacter transmission has been previously reported as weak at best. In Australia, a study comparing temperate and sub-tropical cities reported an inverse relationship between weekly maximums and minimum temperatures, and weekly campylobacteriosis notification incidence in temperate conditions; while a positive association was predicted in sub-tropical conditions. Although we
observed peaks in campylobacteriosis notifications during summer months, seasonal
distribution of *Campylobacter* infection varies in many different geographic and climatic
regions,\(^{23,83}\) indicating a seasonal trigger may not necessarily be related to climate.\(^{19}\) In
Australia, chicken consumption is the main risk factor for *Campylobacter* infection in
humans.\(^ {84}\) Increased risk of infection has been attributed to consumption of inadequately
cooked chicken and eating cooked chicken in restaurants,\(^ {85-87}\) and also warmer weather
activities such as barbeques.\(^ {87-89}\) Riskier food behaviours have also been linked to warmer
weather,\(^ {16}\) suggesting the summer peak may be more relatable to behaviour rather than
weather variables influencing pathogen loads, in the environment and food chain.

**Limitations**
Underreporting of foodborne and waterborne illness is inevitable in disease notification
surveillance systems, especially for enteric infections. Only approximately one in fifteen
cases of enteric infection in Australia are estimated to be reported.\(^ {90}\) Given that surveillance
and testing methods remained consistent throughout the study periods considered, we do not
believe that there is any reason to suggest underrepresentation introduces any systematic
bias into this study. The primary aim of the study was to examine the use of EHI\(_\text{accl}\) to study
the temporal association between heat and disease incidence, and it is unlikely there were
substantial variations annually or inter-seasonally in the recording of cases that might have
introduced bias between years or by disease. Population and socio-economic factors which
may influence disease incidence were not considered. Such factors however do not vary on
weekly timescales and therefore cannot confound temporal associations reported.
Associations presented in the present study may differ by pathogen strain,\(^ {72,91,92}\) however
reliable strain specific data was not available for analysis. Spatial heterogeneity in weather
conditions was also not considered in the analysis. The ACT is a small territory, in which
the vast majority live in urban centres were weather conditions are not likely to vary
dramatically between population hubs.

**Conclusion**
We present a novel tool for investigating the relationship between heat and the incidence of
notified enteric infection. The study complements previous work on understanding the
short-term impact of temperature on enteric illness in Australia. The heat stress index
EHI\(_\text{accl}\) represents short-term temperature anomalies with respect to the recent weeks.
Enteric illness is a significant public health issue and risk of infection is influenced by
pathogen, environmental and behavioural factors that affect foodborne and waterborne
transmission pathways. A better understanding of short term temperature anomalies considering cumulative temperature effects, adds value to the current knowledge. In this study, *Salmonella* and *cryptosporidium* infection were both associated with increased temperature anomalies compared to the average of the previous month. The results highlight the future possibility of efforts to identify potential early warning conditions linked to increased risk of gastrointestinal illness.
## Supplementary material

### Supplementary table 1: Spearman’s correlation coefficients between weekly disease variable counts and mean weekly weather variables

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<tr>
<th></th>
<th>Campylobacter</th>
<th>Salmonella</th>
<th>Cryptosporidiosis</th>
<th>Maximum temperature (ºC)</th>
<th>Rainfall (mm)</th>
<th>EHIAcl</th>
<th>Mean temperature (ºC)</th>
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<td>0.264**</td>
<td>0.141*</td>
<td>0.310**</td>
<td>0.033</td>
<td>0.088</td>
<td>0.315**</td>
</tr>
<tr>
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<td>0.264**</td>
<td>1.00</td>
<td>0.169*</td>
<td>0.309**</td>
<td>0.037</td>
<td>0.005</td>
<td>0.324**</td>
</tr>
<tr>
<td>Cryptosporidiosis</td>
<td>0.141*</td>
<td>0.169*</td>
<td>1.00</td>
<td>0.223**</td>
<td>0.012</td>
<td>-0.12*</td>
<td>0.2343**</td>
</tr>
<tr>
<td>Maximum temperature (ºC)</td>
<td>0.310**</td>
<td>0.309**</td>
<td>0.223**</td>
<td>1.00</td>
<td>-0.109*</td>
<td>0.364**</td>
<td>0.977**</td>
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<td>Rainfall (mm)</td>
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<td>0.012</td>
<td>-0.109*</td>
<td>1.00</td>
<td>0.039*</td>
<td>0.0187</td>
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<tr>
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<td>0.088</td>
<td>0.005</td>
<td>-0.12*</td>
<td>0.364**</td>
<td>0.039*</td>
<td>1.00</td>
<td>0.334**</td>
</tr>
<tr>
<td>Mean temperature (ºC)</td>
<td>0.315**</td>
<td>0.324**</td>
<td>0.2343**</td>
<td>0.977**</td>
<td>0.0187</td>
<td>0.334**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* Statistically significant at p 0.05; **statistically significant at p<0.001
Supplementary Figure 1: Weekly salmonellosis notification rate per 100,000 population and weekly mean rainfall (mm), ACT, 2006-2016

Supplementary Figure 2: Weekly cryptosporidiosis notification rate per 100,000 population and weekly mean rainfall (mm), ACT, 2006-2016
Supplementary Figure 3: Weekly campylobacteriosis notification rate per 100 000 population and weekly mean rainfall (mm), ACT, 2006-2016
References


Chapter 4

*Salmonella* Thyphimurium outbreak of multiple-locus variable-number tandem-repeat analysis (MLVA) types at café in Canberra, February 2017
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Salmonella Typhimurium outbreak of multiple MLVA types at café in Canberra, February 2017

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Prologue

Role

In each of the outbreak investigations that occurred during my time at ACT Health, I played a role as either lead or a member of the investigation team. In this chapter I present the findings from an epidemiological investigation of a large outbreak of salmonellosis associated with a café, which I co-led with the OzFoodNet epidemiologists at ACT Health. During the outbreak I was involved in designing a case-control study and conducting the investigation with the surveillance team. Later, I was responsible for cleaning and analysing the data. The findings from this study have been prepared as a manuscript to be submitted for publication. I have also included reports from the two other noteworthy outbreaks I was involved in during my MAE, as appendices to this Bound Volume (Appendix D). In the first I was part of a multi-disciplinary team responding on-site to an outbreak of gastroenteritis in a visiting school group. I was responsible interviewing cases, onsite data entry and analysis and report writing. I communicated my findings in the ACT Population Health Bulletin (Appendix D.1). In the second outbreak presented, I led a cohort study to identify the source of illness in gastroenteritis cases among guests who attended a wedding. I was responsible for confirming the existence of an outbreak, coordinating the outbreak response – working closely with environmental health colleagues, designing the study, developing the questionnaire, entering and analysing the data and reporting findings (Appendix D.2).

Lessons learnt

Prior to starting the MAE, I worked as a public health officer in the SA Health Communicable Disease Control Branch (CDCB). A key driver behind my MAE application was wanting to acquire the skills to lead an outbreak investigation and to understand different outbreak investigation study designs. From my MAE experience I have achieved this, learning the steps and processes of an outbreak investigation, how to lead an outbreak and how to design and implement case-control and cohort study designs.

I also learnt the importance of working across public health sections. For example, working with environmental health and microbiology colleagues as part of a comprehensive investigation.

Further, I learnt a number of additional skills important to outbreak investigation including:
- How to analyse data from different outbreak study designs, in particular the use of statistical programs to do so.
- Valuable lessons in how to improve my interviewing techniques, and especially the importance of ensuring complete data is collected during interview to improve subsequent analysis.
- The importance of how to plan, organise and conduct a structured after action review following and outbreak investigation to generate learnings and improve future practice.
- How to write an outbreak report.

**Impact of work**

The most important consideration for the HPS in all three outbreaks presented in this bound volume was to identify and remove any continuing or future risk to public health following the identification of an outbreak. Depending on the outbreak scenario, investigations can identify a source of illness, provide evidence to support that an outbreak is not foodborne in origin, and simply describe the characteristics of cases to inform public health decision making.

**Ethics**

These investigations and the data collected was done so under the provision of the *Public Health ACT 1997* and therefore did not require ethics approval.

**Acknowledgments**

Outbreak response is a team job, and I would like to acknowledge that the work presented here reflects that. I am grateful to have been able to work with such skilled health professionals in these high pressure situations. I would like to thank and acknowledge the following people in presenting the following outbreak reports.

My academic and workplace supervisors: Dr Aparna Lal, Ms Rebecca Hundy, Dr Marlena Kaczmarek and Ms April Roberts-Witteveen for their guidance, support, and confidence in me to take the lead during investigations.

The ACT Health OzFoodNet Epidemiologists, Laura Ford, Katie Penfold and Timothy Sloan-Gardner. For their friendship and guidance, and for their expertise and mentorship during each outbreak I participated in.
The EH and ACTGAL teams, and the Health Emergency Management Unit (HEMU). The ability of these teams to come together with the CDCS and produce timely and coordinated outbreak responses is a credit to effective public health response. I acknowledge their role in outbreak investigations presented here and thank them for their support in writing up the findings.

All the staff from the Communicable Disease Control Section at ACT Health: Sue Reid, Rachel Crane, Milica Stefanovic, Michelle Boxx, Jodie Huet, Carolyn Banks, Ashleigh Keeling, Miranda Harris, Sam Kelly, Romaine Huggett and Sandy Wynn. Dr Ranil Appuhamy and Dr Vanessa Johnston.

**Master of Philosophy (Applied Epidemiology) core requirement**

The inclusion of this report in this chapter in my bound volume goes towards fulfilling the Master of Philosophy (Applied Epidemiology) requirement of: Investigation of an acute public health problem.
Salmonella Typhimurium outbreak of multiple-locus variable-number tandem-repeat analysis (MLVA) types at café in Canberra, February 2017

Submitted as an advanced draft for publication

Abstract

Background
In February 2017, ACT Health identified a cluster of salmonellosis cases with a common exposure to a Canberra café. Despite initiating epidemiological and environmental investigation to identify the source and prevent further exposure, two waves of cases with distinct multiple locus variable number of tandem repeats analysis (MLVA) profiles were observed over a greater than two week period.

Methods
A case-control study was undertaken on the initial wave of cases. Controls were identified by booking lists and nomination by cases, and/or controls. Odds ratios were calculated for exposure variables and significant variables were included in logistic regression models. The second wave cases were analysed against the first to identify any differences between the two.

Environmental investigation collected samples of foods, and environmental swabs and human samples were forwarded to reference laboratories for MLVA subtyping.

Results
Results confirmed a total of 75 cases of salmonellosis associated. In the initial wave (n=34) cases were characterised by the MLVA profile 03-17-09-12-523. The secondary wave of cases (n=35) was characterised by the MLVA profile 03-26-13-08-523. In the first wave of case multivariate logistic regression identified smoothies (OR 151.3, CI 8.08–2834.11, P<0.05) as being associated with illness. In the case-case analysis, second wave case were more significantly likely to have consumed cronuts compared to the first (OR 4.7, CI 1.26-16.61 P<0.05). Results from environmental samples and swabs returned positive for presence of Salmonella from multiple kitchen locations.
Conclusion

Two peaks, differentiated by MLVA profile, were observed over the outbreak period. Analytical and environmental investigations were unable to definitively identify a source, however, results of the environmental investigation indicated widespread contamination of the premises with epidemiological evidence strongly suggesting a stick blender as a vehicle for initial contamination.
Outbreak Report & Introduction

*Salmonella enterica* is a common source of foodborne gastroenteritis in humans worldwide.\(^1\) In Australia, approximately 72% of salmonellosis cases are estimated to be of foodborne origin.\(^2\) In 2011, OzFoodNet, Australia’s foodborne disease surveillance network, reported *Salmonella* was the most common aetiological agent identified in foodborne outbreaks in Australia.\(^3\) *Salmonella enterica* serovar Typhimurium (*S. Typhimurium*) is the most commonly notified serovar in Australia, and the serovar most commonly associated with foodborne outbreaks.\(^3\)\(^-\)\(^5\) A recent study of *S. Typhimurium* trends in Australia reported a sustained increase in rates between 2003 and 2013, the largest increase observed in the Australian Capital Territory (ACT).\(^6\) Previously in the ACT, outbreaks associated with *S. Typhimurium* have been reported to be associated with consuming raw or minimally cooked egg-containing foods such as hollandaise sauces or desserts such as tiramisu.\(^7\)\(^-\)\(^9\)

On Friday 3 February 2017, the Health Protection Service (HPS) at ACT Health received two complaints from members of the public regarding gastrointestinal illness among separate groups who had eaten at a Canberra café, on Monday 30 January 2017. One of these complainants had submitted a faecal specimen which was positive for *Salmonella* on Polymerase Chain Reaction (PCR). Routine follow up of all laboratory confirmed salmonellosis cases by Communicable Disease Control Section (CDCS) staff from HPS identified another case who had also eaten at the same café. Environmental Health Officers (EHOs) from HPS inspected the café and found several issues with food handling processes and procedures. An outbreak investigation was commenced which sought to confirm the existence of an outbreak, identify the source of illness, and eliminate any further public health risk.

**Methods**

**Study type**

Initial interviews of complainants and laboratory confirmed *Salmonella* cases were conducted using the standardised OzFoodNet hypothesis generating questionnaire, which includes a detailed three-day food history and captures eating outside of the home exposures. The findings of these interviews led to the hypothesis that illness was associated with consumption of food or beverage at a Canberra café.
We conducted a retrospective case-control study to test this hypothesis. The study was conducted via telephone interview using a structured questionnaire developed from the café’s menu (Appendix 2). The questionnaire sought to confirm date of onset of illness, symptoms, and food and beverage exposure at the cafe. Controls were interviewed using the same questionnaire.

Following enrolment in the initial case-control analysis a second wave of cases, separated in time by environmental health interventions were reported. The case-control study was discontinued during this wave as it became untenable to continue the initial study due the influx of new cases that were prioritised for follow up above contact interviewing. The investigation of second wave cases continued to use the structured questionnaire used in the case-control study. A retrospective case-case analysis was undertaken to identify differences in exposures between the two waves.

**Case definition**

Cases were identified via routine public health investigation of any laboratory confirmed *Salmonella* notifications, or via active case finding through interviewing contacts. To recruit controls, cases were asked during interviews to identify people that had dined with them at the café and were not ill. Controls were also selected from a booking list which was reviewed from the first known exposure date up until the date of the first environmental investigation (29 January to 3 February, 2017). There were no constraints on control selection by age or sex providing the control had dined at the café and gave consent to be included in the investigation.

For the case-control study a confirmed case was defined as anyone who reported visiting or consuming products from the café between 29 January and 10 February 2017, and who subsequently developed gastroenteritis (diarrhoea with or without abdominal pain) within 7 days of exposure, as well as having a faecal sample positive for *Salmonella* with a MLVA profile 03-17-09-12-523. In the investigation of the second wave of cases a confirmed case was defined as per the case-control study but with an exposure after 3 February until 14 February 2017 and a faecal sample positive for *Salmonella*, MLVA profile 03-26-13-08-523.

Probable cases were defined as per confirmed cases, but were not further typed using MLVA. Suspected cases were considered as an individual who experienced an onset of
gastroenteritis between 29 January and 14 February 2017 and reported visiting or consuming product from the premise within 7 days of symptom onset. Secondary cases were defined as isolation of *Salmonella* in individuals who had household contact with a confirmed or suspected outbreak case within 7 days prior to onset, and had an onset within three days after their contact. Cases were excluded from the univariate and multivariate analysis where: there was an unknown onset date or exposure date, symptom onset was greater than 7 days following eating at the premise and where the case.

Probable, suspected and secondary cases were not considered in the case-control or case-case analysis for either wave. In the second wave three confirmed cases were excluded from the case-case analysis due to being interstate residents that were not interviewed using the standardised outbreak investigation questionnaire and one case, in an infant, was excluded as they had not consumed any food or beverage products.

**Epidemiological investigation**

Data were collected and entered into Microsoft Excel 2007 (Microsoft, USA) and analysed using Stata IC version 13 (StataCorp LP, College Station, TX, USA). Univariate analysis of exposures in the initial wave case-control study was conducted to calculate crude odds ratios (OR), 95% confidence intervals (CI) and *P* values. Case and control demographics, such as sex, were compared using Pearson’s chi-square test, while age was compared using a student’s *t*-test. A Mann Whitney Wilcoxon Rank Sum test was used to test for difference in exposure date between cases and controls. All findings were considered significant at *P*<0.05. A multivariate logistic regression model was constructed to adjust for potential confounders with age and sex retained and using food items that had a *P* value <0.05 after univariate analysis. Backward stepwise elimination was employed to remove non-significant variables (*P*>0.05) or collinear variables from the model using a likelihood ratio test to determine whether removal of exposure variables were significantly associated (*P*<0.05) with cases. A Likelihood ratio test was then used to compare the full and reduced model, and a Homer and Lemeshow test was carried out to test model fit.

A retrospective case-case analysis was conducted for the second wave of cases. Pearson’s chi-square and a student’s *t*-test were used to compare demographic characteristics between cases in the first and second wave. Food frequencies were generated to identify differences in food consumption compared to first wave cases using the same methodology detailed above.
Outbreak investigation

Environmental investigation
Environmental Health Officers (EHOs) from HPS inspected the café twice on 3 February 2017 following initial complaints. Statutory food samples were obtained from raw egg products, smoothie mixtures and ingredients. Extensive environmental swabbing was undertaken. Seven follow-up inspections were conducted by EHOs between 6 and 17 February 2017. During these inspections additional swabbing and further sampling of cleaning items and food items were conducted.

Laboratory investigation
Faecal specimens from cases were tested for enteric pathogens using either PCR or by traditional culture methods. Where *Salmonella* was cultured, isolates were serotyped and identified using MLVA at the Microbiological Diagnostics Unit (MDU), University of Melbourne, Victoria, or the New South Wales Enteric Reference Laboratory, Institute for Clinical Pathology and Medical Research (ICPMR), Sydney.

Food and environmental samples and swabs collected during EHO inspections were tested for presence of *Salmonella* (and other pathogens), by the Australian Capital Territory Government Analytical Laboratory (ACTGAL) using standard food and environmental laboratory methods. Where *Salmonella* was cultured, isolates were serotyped and identified using MLVA at MDU.

Ethics
Ethics approval was not sought as this investigation and the data collected was done so under the provision of the *Public Health Act 1997* and does not require ethics approval.

Results

Epidemiological investigation
A total of 75 cases of salmonellosis meeting the case definition for confirmed or probable cases were identified in people who reported eating at the same Canberra café between 29 January and 14 February 2017. Another 34 suspected cases reported symptoms of gastroenteritis, but were not tested, and 10 secondary cases were identified through case interviews, complaints and active case finding (Figure 1). Thirty-four cases were typed as *S. Typhimurium* MLVA 03-17-09-12-523 and reported eating at the premise between 29 January and 10 February 2017. Thirty-nine cases were typed as *S. Typhimurium* MLVA 03-
26-13-08-523 and reported eating at the premise between 5 and 14 February 2017 (Figure 2). Two cases were not further typed and reported as probable. Among confirmed, probable and suspected cases, there were 38 emergency department presentations and 20 hospitalisations reported. The median age of all confirmed, probable, secondary and suspected cases was 23 years (range <1-83 years) and 66% (78/119) were female.

Figure 1: Epidemic curve of S.Typhimurium 03-17-09-12-523 and 03-26-13-08-523 cases by date of exposure and case classification

**MLVA 03-17-09-12-523 – case-control study**

Figure 1 shows the epidemiological curve by onset date of all identified cases by classification according to the case definition. The median age of cases (n=34) was 18 years (range 2 to 83 years) and 74% (25/34) were female. The median incubation period was 47.8 hours (range 9.3 to 135 hours, interquartile range (IQR) 24.3 hours). Among cases, in addition to diarrhoea (experienced by all), 24% (8/34) experienced bloody diarrhoea, 91% (31/34) experienced fever, 94% (32/34) experienced abdominal pain, 74% (25/34) experienced nausea and 55% (19/34) experienced vomiting. Thirty cases (88%) consulted either a general practitioner or presented at emergency departments, and 8 cases (26%) were hospitalised for their illness. As most cases were still unwell at the time of interview, information about the duration of illness was unable to be ascertained consistently for analysis. A total of 34 unmatched controls were recruited into the study. The mean age of
controls was 47 (range 5–77 years), with 64% (22/34) being female. The distribution of sex between cases and controls was not significantly different ($P>0.05$) and there was no significant difference between the exposure dates ($P>0.05$). There was a significant difference in the mean ages between groups ($P<0.05$) (Table 1).

**Table 1: Age and sex distribution by cases MLVA 03-17-09-12-523 and MLVA 03-26-13-08-523 and controls**

<table>
<thead>
<tr>
<th></th>
<th>Case – MLVA 03-17-9-12-523</th>
<th>Control</th>
<th>$P$ value*</th>
<th>Case – MLVA 03-26-13-08-523</th>
<th>$P$ value**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>25</td>
<td>22</td>
<td>0.43 0.23</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>9</td>
<td>12</td>
<td></td>
<td>14</td>
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<td><strong>Age</strong></td>
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<tr>
<td>Mean</td>
<td>24</td>
<td>47</td>
<td>&lt;0.001 0.18</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>16</td>
<td>3</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>15-39</td>
<td>11</td>
<td>9</td>
<td></td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>40-59</td>
<td>5</td>
<td>12</td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>60+</td>
<td>2</td>
<td>10</td>
<td></td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

*Case-control comparison  
**Case-case comparison

Results of the univariate and multivariate analysis are shown in Table 2. Of the two smoothies on the menu, berry smoothie was significantly associated with illness (crude OR 60.5, 95% CI 2.27–792.02 $P<0.05$). Mango smoothies, vanilla shakes and cronuts, were among most frequently consumed food items among cases and were statistically significant in univariate analysis, but had no exposures among controls. To examine the combined effect of smoothies we created an ‘any smoothie’ variable that was significantly associated with illness in univariate analysis (crude OR 60.5, 95% CI 7.59–2569.08 $P<0.05$). In the final multivariate model, we considered the ‘any smoothie’ variable (adjusted OR 151.3, 95% CI 8.08–2834.11 $P<0.05$), as collinearity eliminated berry smoothie from the model. Sensitivity analysis was used to confirm the ‘any smoothie’ model was a better fit compared to a model without the combined variable.
MLVA 03-26-13-08-523 – case-case analysis

Cases in the second wave were predominately MLVA 03-26-13-05-523 (Figure 2), other confirmed cases in this wave were the same as the first wave. All 39 confirmed cases reported attending the premises between 5 and 14 February 2017. The median age was 27 years (range <1 to 76 years) and 64% (25/39) were female. The distribution of sex between initial cases (MLVA profile 03-17-09-12-523) and the second wave of cases (MLVA profile 03-26-13-08-523) did not differ significantly ($P$>0.05). Neither was there a significant difference between the mean ages of the two groups ($P$>0.05) (Table 1).

![Figure 2: Epidemic curve of S.Typhimurium 03-17-09-12-523 and 03-26-13-08-523 cases by date of exposure.](image)

The median incubation period for the second wave of cases was 40 hours (range 4 to 111 hours, interquartile range 62.2 hours). In addition to diarrhoea experienced by all, 95% (37/39) experienced fever, 92% (36/39) experienced abdominal pain, 90% (35/39) experienced nausea, and 49% (19/39) experienced vomiting. Ten cases (26%) were hospitalised and 39% (15/39) of cases presented at an emergency department directly or in addition to a prior consultation with a general practitioner. As most cases were still unwell at the time of interview, information about the duration of illness was not ascertained.
Consumption of cronuts was more frequent in cases of this MLVA pattern compared to the first group of cases. Cases of confirmed *Salmonella* MLVA 03-26-13-08-523 were more likely to have eaten cronuts in univariate (crude OR 5.00, 95% CI 1.30–23.29, *P*<0.05) and multivariate analysis (adjusted OR 4.7, 95% CI 1.26–16.6 *P*<0.05). Cronuts were the only food item considered in the multivariate analysis. No other food items were consumed in high enough frequency to be considered suspicious or identified in the initial univariate analysis.
Table 2: Univariate and Multivariate analysis for MLVA 03-17-09-12-523 control analysis and MLVA 03-26-13-08-523 case-case analysis of cafe menu items that were most frequently consumed and items included in the regression analysis

<table>
<thead>
<tr>
<th>MLVA 03-17-09-12-523 (n=34) - Case-control analysis</th>
<th>MLVA 03-26-13-08-523 (n=35) - Case-case analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Univariate analysis</strong></td>
<td><strong>Multivariate analysis</strong></td>
</tr>
<tr>
<td>N (% exposed*)</td>
<td>Crude odds ratio (95% CI)</td>
</tr>
<tr>
<td>'any smoothie'</td>
<td>22 (64.7%)</td>
</tr>
<tr>
<td>Mango smoothie</td>
<td>14 (41.2%)</td>
</tr>
<tr>
<td>Berry smoothie</td>
<td>12 (35.3%)</td>
</tr>
<tr>
<td>Vanilla shake</td>
<td>6 (17.7%)</td>
</tr>
<tr>
<td>Cronut</td>
<td>4 (11.8%)</td>
</tr>
<tr>
<td>Orange juice</td>
<td>1 (2.9%)</td>
</tr>
<tr>
<td>Watermelon juice</td>
<td>2 (5.9%)</td>
</tr>
<tr>
<td>Pastry</td>
<td>3 (8.8%)</td>
</tr>
<tr>
<td>Cake</td>
<td>3 (8.8%)</td>
</tr>
<tr>
<td>Coffee</td>
<td>2 (5.9%)</td>
</tr>
</tbody>
</table>

* Denotes exposure to the variable
Environmental investigation

EHOs inspected the premises nine times during the investigation. Supplementary table 1 shows the date of swab and sample collection and results and a timeline of the environmental investigation is provided in Appendix 3.

The initial two inspections occurred on Friday 3 February 2017. Several non-compliance issues were identified during the first inspection relevant to the storage or raw eggs and raw egg products, stock rotation and pre-prepared food item storage, and sanitation of equipment used to prepare raw egg products and other products. Notably a stick blender was used to make a number of pre-prepared products including raw egg sauces and smoothie base mixtures. The smoothie base recipe itself did not include raw egg. A pre-mix smoothie base batch which was date labelled 24/1/17 was still in use (sampled) and verbal advice was given to proprietor about stock rotation. In addition, the pre-mix smoothie batches were kept in the same fridge as uncovered raw egg products, and temperature control practices of the pre-mix smoothie base were unable to be confirmed. At the subsequent inspection all products made with the stick blender were discarded. An Improvement Notice was also issued under the Food Act 2001 to increase standards across processes, sanitisation of equipment, and food safety training for food handlers. Samples of smoothie mixture and various ingredients, raw egg products and environmental swabs, including the stick blender and milkshake makers were collected. (Supplementary table 1).

On Monday 6 February 2017 a Prohibition Order was served to the premises under the Food Act 2001 on the production of smoothies and of raw egg products (hollandaise sauce, raw egg aioli and mayonnaise). Samples from cleaning utensils, cloths and tea towels from service and kitchen areas were collected Supplementary table 1.

A presumptive positive result – later confirmed for Salmonella – from a disposable cloth and tea towel used in the kitchen and collected on 6 February 2017 (Supplementary table 1), initiated a further inspection on Thursday 9 February 2017. All disposable cloths and tea towels in use were discarded. On Monday 13 February 2017 another inspection was conducted to allow for follow-up testing. Environmental swabs were collected from various kitchen and service areas and samples of various cloth and tea towels were taken. Samples and swabs from syringes that contained chocolate or strawberry sauce and were served with cronuts were also taken. The existence of the sauce served with cronuts had not been identified in the epidemiological investigation. These sauces were pre-made and did not contain any raw egg based products or require temperature controlled storage.
The following day, Tuesday 14 February 2017, a second Prohibition Order was issued ordering the business to cease trading. A closure of business process was conducted by EHOs later that day, all ready-to-eat foods stored or displayed at the premises which did not require a further processing step to render them safe to eat were discarded and a deep clean and sanitisation of all fixtures, fittings, equipment and utensils commenced. Food samples obtained at time inspection all tested negative (Supplementary table 1). Follow-up testing after the premises re-opened on 16 February 2017 all tested negative for any pathogen (Supplementary table 1).

**Laboratory investigation**

Microbiology results from the environmental investigation are summarised Supplementary table 1. In total nine positive samples and one positive swab for *Salmonella* were reported from specimens collected on either 6 or 13 February 2017. A proportion of human and environmental isolates further typed at MDU and ICMPR were whole genome sequenced (WGS) for the second wave cases with the MLVA profile 03-26-13-08-523 (results not presented here).

**Discussion**

This investigation details a large outbreak *S. Typhimurium* with two distinct MLVA patterns in cases who all ate at the same café in Canberra over a greater than two week period. Environmental health investigation discovered food safety issues at the premise and environmental sampling results were positive for *S. Typhimurium*.

The initial wave of cases was characterised by the MLVA pattern 03-17-09-12-523. Having consumed smoothies was significantly associated with illness in univariate and multivariate analysis. A pre-prepared fruit mixture used to make smoothies was made using a stick blender. That stick blender was also used for the preparation of raw egg products, such a hollandaise sauce. Inadequate sanitation of blenders between raw egg and non-raw egg usage can lead to cross contamination. Stick blenders, or similar food processors have been associated with *Salmonella* outbreaks previously following inappropriate sanitation. EHOs took swabs from the stick blender at the café along with samples of available smoothie mixtures which all tested negative for *Salmonella*. The smoothie mixture sampled however could not be confirmed to be the same served during the exposure period. The smoothie mixture itself was observed to have been stored next to uncovered raw egg products in a fridge. Batches of the mixtures were also observed to have been in stock rotation for long periods of time after preparation, and no temperature control practices were observed regarding use of the mixture, increasing the possibility for bacterial amplification if cross contamination had occurred. As a public health precaution all products
made with the stick blender in current service were disposed of during the second inspection on Friday 3 February 2017 (Appendix 3) and the premise was requested to undertake a thorough cleaning processes of food preparation equipment and areas.

The second peak of cases was characterised by the MLVA profile 03-26-13-08-523 and exposure to the café following the prohibition on smoothie and raw egg product sales. Demographic characteristics were similar between the two waves of cases, and the menu did not change, with the exception of the removal or smoothies, milkshakes and raw egg products. The case-control analysis was not continued for this group due to resource availability. A case-case analysis was conducted to identify any differences in exposure to specific food items between the two waves to help generate a hypothesis to focus the ongoing environmental investigation. Cronuts, a pre-made pastry served with a syringe of sauce, were the only food item to be significantly associated with greater likelihood of consumption by cases with a MLVA 03-26-13-08-523. No samples from cronuts were able to be obtained and the analysis is unable to define association between illness and cronut consumption, meaning the increased frequency of consumption in the MLVA 03-26-13-08-523 cases may be a chance finding.

Pathogen testing of cleaning products (disposable cloths and tea towel) samples and environmental swabs collected throughout the venue after the initial prohibition order on smoothies and raw egg products detected the presence of *Salmonella* MLVA 03-26-13-08-523. *Salmonella* has been shown to survive on stainless steel surfaces, kitchen utensils, sponges/cloths and food preparation surfaces up to hours or days after initial contact with microorganisms in experimental conditions. Samples and swabs were collected from various parts of the kitchen and service areas implying widespread contamination of the café.

The incidence of *S. Typhimurium* and the number of outbreaks associated with *S. Typhimurium* have increased in Australia. Infection with *S. Typhimurium* has been linked to a range of food vehicles, predominantly eggs, and poultry but also pork, beef fresh primary produce, and dairy products. Contamination of, and pathogen survival on, egg shells with *Salmonella* has been reported, and under experimental conditions *Salmonella* contamination was observed on hands following the breaking of intact egg shells and on kitchen utensils used to mix egg dishes. Cross-contamination events linked to eggs have resulted in outbreaks of *S. Typhimurium* in Australia previously. It is plausible, given the epidemiological findings and environmental evidence for improper food storage and cleaning and sanitation practices, that any cross-contamination which occurred at the café may have been associated with eggs. However, with no positive samples or swabs from eggs or raw egg products, or any epidemiological
association between raw-egg food and illness, we are unable to confirm a link between this outbreak and eggs.

Limitations
The investigation was limited in that *Salmonella* was not found in any of the foods implicated in the epidemiological investigation. The results of the investigation suggest that a breakdown in cleanliness, temperature control and good food handling practices are likely to have caused the outbreak, however the epidemiological investigation is unable to confirm the likely hypothesis.

The time from exposure to the commencement of the case-control study was approximately one week, which may have helped to reduce misclassification subsequent to recall bias. The recruitment of controls via booking lists, and through known cases and/or controls was a practical strategy in response to this outbreak. We consider these methods appropriate in an acute public health response to scenario. A matched case-control study was not performed due to the nature of the outbreak and difficulty in finding appropriate controls, although this would have helped to manage potential confounding and bias. The descriptive epidemiology defined a significant difference in mean age between cases and controls. Whilst it is plausible that younger aged cases had a higher propensity to ordering smoothies compared with older controls thus causing an overestimation of effect size, the strength of the association in multivariable logistic regression, consistent with environmental observations, suggests our conclusions remain valid.

The width of confidence intervals for the effect size does reveals some imprecision around the study’s primary findings. The wide confidence intervals observed are due to a limited sample size of cases and controls due to the nature of the outbreak and the difficulties in finding controls during a rapid public health response. The inability to continue the case-control study into the second wave of cases clearly limited the ability of the investigation to identify further associations between illness and exposure. Although a case-case analysis was utilised for hypothesis generating purposes, the investigation is constrained to identifying association in the first wave of cases only.

Conclusion
Two peaks, differentiated by MLVA profile, were observed over the outbreak period. A case-control study for the initial wave of illness (MLVA 03-17-09-12-523) suggested an association between smoothies and illness. A case-case analysis of the subsequent peak (MLVA 03-26-13-08-523) identified that MLVA 03-26-13-08-523 cases were positively associated with increased consumption of cronuts. The environmental investigation findings identified plausible
mechanisms for cross contamination via raw egg exposure, however we were unable to substantiate these findings epidemiologically beyond identifying the positive association between smoothies and the initial wave of cases. Public health interventions were implemented early in the outbreak following initial findings, but failed in stopping the outbreak. Identification of *S. Typhimurium* MLVA 03-26-13-08-523 from environmental samples matched the second wave of cases. A breakdown of proper food preparation, handling and storage practices and ineffective cleaning and sanitisation of surfaces and equipment, were likely contributing factors to the ongoing outbreak. Despite not identifying a source of contamination, this outbreak investigation highlights the risk of wide spread contamination of food premises, and the difficulties in applying effective epidemiological methodology to identify the source of the outbreak.
References


Appendix 1: Environmental investigation findings

Supplementary table 1: Type and location of samples and swabs taken during environmental health inspections and laboratory results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Location</th>
<th>Date collected</th>
<th>Result (Salmonella presence)</th>
<th>MDU MLVA profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foods</td>
<td>Frozen strawberries</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frozen mixed berries</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mayonnaise</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frozen Mango</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coconut Milk</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mango smoothie</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Berry smoothie</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td>Swab</td>
<td>Stick blender blade cavity</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fridge 2 door handle</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Milkshake machine 1</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stick blender blade</td>
<td>03/02/2017</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Interior fridge 1 door right</td>
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<td>Absent**</td>
<td></td>
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<tr>
<td></td>
<td>Interior 1 fridge door left</td>
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<td>Absent**</td>
<td></td>
</tr>
<tr>
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<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fridge 1 door Handle</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stick blender shaft cavity</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Milkshake machine 2</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Stick blender handle</td>
<td>03/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stick blender shaft</td>
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<td></td>
</tr>
<tr>
<td>Tea towel</td>
<td>Bucket</td>
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<td>Present**</td>
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<td></td>
<td>Dishwasher</td>
<td>06/02/2017</td>
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<td>Storage area</td>
<td>06/02/2017</td>
<td>Present**</td>
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<td>Under fridge</td>
<td>06/02/2017</td>
<td>Present**</td>
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<td></td>
<td>Front bench</td>
<td>06/02/2017</td>
<td>Absent**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kitchen bench</td>
<td>13/02/2017</td>
<td>Not detected*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waiter’s station</td>
<td>13/02/2017</td>
<td>Not detected*</td>
<td></td>
</tr>
<tr>
<td>Cloth (chux)</td>
<td>Kitchen bench</td>
<td>06/02/2017</td>
<td>Present**</td>
<td>03-26-13-08-523</td>
</tr>
<tr>
<td></td>
<td>Date</td>
<td>Status</td>
<td>Code</td>
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<td>------------</td>
<td>----------</td>
<td>---------------</td>
<td></td>
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<tr>
<td><strong>Milkshake area</strong></td>
<td>06/02/2017</td>
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<td>03-26-13-08-523</td>
<td></td>
</tr>
<tr>
<td>Handwash basin</td>
<td>06/02/2017</td>
<td>Present</td>
<td>03-26-13-08-523</td>
<td></td>
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<tr>
<td><strong>Swab</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen bench</td>
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<td>Not detected*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fridge door</td>
<td>13/02/2017</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>13/02/2017</td>
<td>Not detected*</td>
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</tr>
<tr>
<td><strong>Dishes – bench</strong></td>
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<td>Present**</td>
<td>03-26-13-08-523</td>
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</tr>
<tr>
<td>Bench top – Waiter’s station</td>
<td>13/02/2017</td>
<td>Not detected*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bench – Milkshake area</td>
<td>13/02/2017</td>
<td>Not detected*</td>
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<tr>
<td>Service area</td>
<td>13/02/2017</td>
<td>Not detected*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main preparation bench</td>
<td>13/02/2017</td>
<td>Not detected*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen door</td>
<td>13/02/2017</td>
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<td></td>
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<tr>
<td><strong>Cloth (chux)</strong></td>
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<tr>
<td>Kitchen bench</td>
<td>13/02/2017</td>
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<td></td>
<td></td>
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<tr>
<td><strong>Dishwashing area</strong></td>
<td>13/02/2017</td>
<td>Present**</td>
<td>03-26-13-08-523</td>
<td></td>
</tr>
<tr>
<td><strong>Milkshake bench</strong></td>
<td>13/02/2017</td>
<td>Present**</td>
<td>03-26-13-08-523</td>
<td></td>
</tr>
<tr>
<td>In bucket</td>
<td>13/02/2017</td>
<td>Not detected*</td>
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<tr>
<td><strong>Scourer</strong></td>
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<td></td>
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<tr>
<td>Kitchen</td>
<td>13/02/2017</td>
<td>Present**</td>
<td>03-26-13-08-523</td>
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<tr>
<td><strong>Sponge</strong></td>
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<td>Dishwashing area</td>
<td>13/02/2017</td>
<td>Present**</td>
<td>03-26-13-08-523</td>
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<tr>
<td><strong>Foods</strong></td>
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<tr>
<td>Cronuts</td>
<td>14/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked chicken</td>
<td>14/02/2017</td>
<td>Absent**</td>
<td></td>
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<tr>
<td>Pancakes</td>
<td>14/02/2017</td>
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<tr>
<td>Cronut sauce red</td>
<td>14/02/2017</td>
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<td></td>
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<tr>
<td>Cronut syringe (red)</td>
<td>14/02/2017</td>
<td>Absent**</td>
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<tr>
<td>Cronut sauce brown</td>
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<tr>
<td>Cronut syringe (brown)</td>
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<tr>
<td><strong>Sponge</strong></td>
<td></td>
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<td>Dish washing bench area</td>
<td>16/02/2017</td>
<td>Not detected*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under bench area kitchen</td>
<td>16/02/2017</td>
<td>Not detected*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior of dish washer</td>
<td>16/02/2017</td>
<td>Not detected*</td>
<td></td>
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</tr>
<tr>
<td>Interior of dish washer #2</td>
<td>16/02/2017</td>
<td>Not detected*</td>
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</tr>
<tr>
<td>Main preparation bench</td>
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<tr>
<td><strong>Sponge swab</strong></td>
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<tr>
<td>Floor drain &amp; area around drain</td>
<td>16/02/2017</td>
<td>Not detected*</td>
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<tr>
<td>Swab</td>
<td>Date</td>
<td>Result</td>
<td></td>
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<tr>
<td>----------------------</td>
<td>------------</td>
<td>-------------</td>
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<tr>
<td>Display Cabinet interior</td>
<td>16/02/2017</td>
<td>Not detected*</td>
<td></td>
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</tr>
<tr>
<td>Service area bench top</td>
<td>16/02/2017</td>
<td>Not detected*</td>
<td></td>
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<tr>
<td>Dish washer tray</td>
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<td></td>
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<tr>
<td>Trays in kitchen</td>
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<td>Absent**</td>
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<tr>
<td>Fridge #2 seals</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior fridge #2</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
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<tr>
<td>Kitchen sink #2</td>
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<td></td>
</tr>
<tr>
<td>Kitchen hand wash station</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixer</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior fridge #1</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under bench racks kitchen</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage shelf kitchen</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fridge #1 seals</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
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<tr>
<td>Handwash station service area</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milkshake maker #1</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milkshake maker #2</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milkshake maker #3</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal cup with scoop</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straw container</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
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<tr>
<td>Freezer handlers serve area</td>
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<td></td>
</tr>
<tr>
<td>Storage racks service area</td>
<td>16/02/2017</td>
<td>Absent**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service area</td>
<td>16/02/2017</td>
<td>Not detected*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Detected reflects a quantitative analysis where a microbial count is determined
** Absent reflects a qualitative analysis where the presence or absence of an organism is determined
Appendix 2: Outbreak investigation questionnaire

Outbreak Name: 20170107 Ricardos Jamison

OUTBREAK INVESTIGATION

CASE QUESTIONNAIRE

Interviewer: ______________

<table>
<thead>
<tr>
<th>Attempt</th>
<th>Date</th>
<th>Time</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>___ / ___ / ______</td>
<td>______ am / pm</td>
<td>______</td>
</tr>
<tr>
<td>2</td>
<td>___ / ___ / ______</td>
<td>______ am / pm</td>
<td>______</td>
</tr>
<tr>
<td>3</td>
<td>___ / ___ / ______</td>
<td>______ am / pm</td>
<td>______</td>
</tr>
<tr>
<td>4</td>
<td>___ / ___ / ______</td>
<td>______ am / pm</td>
<td>______</td>
</tr>
</tbody>
</table>

‘Hello. My name is _______________________________ and I’m calling from ACT Health.’

‘Officers from the ACT Health Protection Service are currently investigating a number of gastroenteritis infections in the community and we are trying to find the potential source for this infection. We would like your assistance in answering some questions regarding your (or case’s name) illness and foods eaten before becoming ill. It should only take 10 – 15 minutes to complete.’

‘The information from this survey is confidential and is being collected in accordance with the Public Health Act 1997. Only authorised officers from ACT Health will be involved in examining the information. This limits the amount of information that we are able to feedback about the investigation.’

Note: The following preliminary information can be recorded prior to the interview if known.

<table>
<thead>
<tr>
<th>Personal details</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Name: ____________________________</td>
</tr>
<tr>
<td>Last Name: ____________________________</td>
</tr>
<tr>
<td>Telephone: ____________________________ (Mobile)</td>
</tr>
<tr>
<td>Date of Birth: _____ / _____ / _______</td>
</tr>
</tbody>
</table>

Call Outcomes

OC1 – No Answer
OC2 – Subject not home, call back
OC3 – Appointment to call back
OC4 – Refusal
OC5 – Interviewed
## Event details

In the last 14 days did you eat at Ricardos Jamison? Yes ☐ No ☐ (If no, END interview)

What day did you eat at Ricardo’s?

- Sun 29 Jan ☐
- Mon 30 Jan ☐
- Tue 31 Jan ☐
- Wed 1 Feb ☐
- Thu 2 Feb ☐
- Fri 3 Feb ☐
- Other day: __________________________

Who did you eat with (names & contact details)?

What time did you eat: __________________________ AM / PM

## Food eaten

<table>
<thead>
<tr>
<th>Menu item</th>
<th>Extra details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drinks</strong></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>☐ Yes ☐ No ☐ DK</td>
</tr>
<tr>
<td>Tea</td>
<td>☐ Yes ☐ No ☐ DK</td>
</tr>
<tr>
<td>Fresh orange juice</td>
<td>☐ Yes ☐ No ☐ DK</td>
</tr>
<tr>
<td>Pineapple, cucumber, mint &amp; elderflower juice</td>
<td>☐ Yes ☐ No ☐ DK</td>
</tr>
<tr>
<td>Carrot, orange &amp; ginger juice</td>
<td>☐ Yes ☐ No ☐ DK</td>
</tr>
<tr>
<td>Beverage</td>
<td>Yes</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Watermelon, apple, pineapple &amp; mint juice</td>
<td></td>
</tr>
<tr>
<td>Berry smoothie</td>
<td></td>
</tr>
<tr>
<td>Mango smoothie</td>
<td></td>
</tr>
<tr>
<td>Iced coffee</td>
<td></td>
</tr>
<tr>
<td>Iced nutella</td>
<td></td>
</tr>
<tr>
<td>Iced salted caramel</td>
<td></td>
</tr>
<tr>
<td>Iced Oreo &amp; peppermint</td>
<td></td>
</tr>
<tr>
<td>Iced mocha</td>
<td></td>
</tr>
<tr>
<td>Nutella milkshake</td>
<td></td>
</tr>
<tr>
<td>Salted caramel milkshake</td>
<td></td>
</tr>
<tr>
<td>Oreo &amp; peppermint milkshake</td>
<td></td>
</tr>
<tr>
<td>Vanilla milkshake</td>
<td></td>
</tr>
<tr>
<td>Chocolate milkshake</td>
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</table>

**Breakfast items**

<table>
<thead>
<tr>
<th>Breakfast item</th>
<th>Yes</th>
<th>No</th>
<th>DK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big breakfast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not so big breakfast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green eggs &amp; ham benedict</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Add hollandaise sauce?  
☐ Yes ☐ No ☐ DK
Add avocado?  
☐ Yes ☐ No ☐ DK
Add chorizo?  
☐ Yes ☐ No ☐ DK
<table>
<thead>
<tr>
<th>Item</th>
<th>Yes</th>
<th>No</th>
<th>DK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotcakes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coconut crusted French toast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoked salmon quesadilla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet potato chickpea felafel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast fritters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bircher muesli</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit salad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toasted granola</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast roll</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add avocado?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Add hash brown?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit Toast &amp; Co</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch items</td>
<td></td>
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</tr>
<tr>
<td>Fish &amp; chips, lemon and aioli</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Calamari (citrus aioli)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fish tacos</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thai beef salad</td>
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<td></td>
<td></td>
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<tr>
<td>Chicken salad</td>
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<tr>
<td>Haloumi salad</td>
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</tr>
<tr>
<td>Pulled pork burger</td>
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<tr>
<td>K.F.C. burger</td>
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<tr>
<td>Cheese Burger with American mustard aioli</td>
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<tr>
<td>Steak Sandwich</td>
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</tr>
<tr>
<td>Roast chicken sandwich with lime aioli</td>
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</tr>
<tr>
<td>Open mushroom sandwich</td>
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<tr>
<td>Turkey breast sandwich</td>
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<tr>
<td>Cakes/Pastries</td>
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<tr>
<td>Cronut</td>
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### Outbreak investigation

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<tr>
<td><strong>Croissant</strong></td>
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<td><strong>Scones</strong></td>
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<tr>
<td><strong>Cake</strong></td>
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<tr>
<td><strong>Other cakes/pastries/desserts:</strong></td>
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<tr>
<td><strong>Kids Menu</strong></td>
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<tr>
<td>Kids pancakes</td>
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</tr>
<tr>
<td>Nutella croissant</td>
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<tr>
<td>Egg on toast</td>
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</tr>
<tr>
<td>Fruit toast</td>
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<td></td>
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<tr>
<td>Plain croissant</td>
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</tr>
<tr>
<td>Ham &amp; cheese croissant</td>
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<tr>
<td>Kids BLT</td>
<td></td>
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</tr>
<tr>
<td>Fish N Chips</td>
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<tr>
<td>Cheeseburger</td>
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<tr>
<td>Chips</td>
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**Other Commercial venues**

<table>
<thead>
<tr>
<th>Did you eat out at any other commercial venues in the last 7 days?</th>
<th>Yes</th>
<th>No</th>
<th>DK</th>
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<tbody>
<tr>
<td>If yes:</td>
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<tr>
<td>Where:</td>
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<tr>
<td>Date:</td>
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<td></td>
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<tr>
<td>Time:</td>
<td></td>
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</tr>
<tr>
<td>What did you eat?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Date:</td>
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<td></td>
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<tr>
<td>Time:</td>
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</tbody>
</table>
Medical & diagnostic information

'We would like to obtain some detail on whether or not you became sick, and if so, what kind of symptoms you experienced.'

Did (you / your child) experience any of the following symptoms?

<table>
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<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>DK/NS</th>
<th>Onset Date</th>
<th>Indicate first symptom experienced</th>
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<tbody>
<tr>
<td>Fever</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
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<tr>
<td>Abdominal pain</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td>.....</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td>.....</td>
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<tr>
<td>Blood in stools</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td>.....</td>
</tr>
<tr>
<td>Nausea</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td>.....</td>
</tr>
<tr>
<td>Vomiting</td>
<td></td>
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<td></td>
<td>___ / ___ / _____</td>
<td>.....</td>
</tr>
<tr>
<td>Headache</td>
<td></td>
<td></td>
<td></td>
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<td>.....</td>
</tr>
<tr>
<td>Lethargy</td>
<td></td>
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<td>J/M Pain</td>
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<tr>
<td>Other symptoms</td>
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Specify: ________________________________________________

At what time did (your / your child’s) gastrointestinal symptoms begin? ______ AM / PM

(Vomiting, diarrhoea, or stomach cramps only)
For how long did (your / your child’s) diarrhoea or vomiting symptoms last? _______ Hours / Days

<table>
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<tr>
<th>Did you consult a GP for your illness?</th>
<th>Yes</th>
<th>No</th>
<th>DK/NS</th>
<th>Specify</th>
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<th>Were (you/ your child) admitted to hospital overnight?</th>
<th>Yes</th>
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<th>DK/NS</th>
<th>Specify</th>
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<th>Admission</th>
<th>Nights stayed</th>
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<td>_____ / _____ / _____</td>
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<table>
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<tr>
<th>Discharge</th>
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<td>_____ / _____ / _____</td>
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<tr>
<th>Have (you/ your child) provided a sample for pathology testing?</th>
<th>Yes</th>
<th>No</th>
<th>DK/NS</th>
<th>Specify</th>
<th>Location</th>
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<tr>
<th>Will (you/ your child) provide a sample for pathology testing?</th>
<th>Yes</th>
<th>No</th>
<th>DK/NS</th>
<th>Specify</th>
<th>Location</th>
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</table>

Were (you / Was your child) treated for illness?

If yes: ☐ Rehydration ☐ Antibiotics ☐ other, please describe:

CONCLUSION

Thanks for your time today.

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

We do this by trying to find out what is likely to have caused your illness and also by providing you with information to reduce the spread of illness to others.

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

If we have any further questions, could we contact you again? ☐ Y ☐ N
Appendix 3: Outbreak time line of key events

- **HPS receives email complaints**
- **EH conduct 1st & 2nd inspection**
- **Case control study begins**
  - EH 3rd inspection - PO on production of raw egg products and smoothies
  - Samples collected - tea towels & chux
- **ACTGAL result:** Presumptive *Salmonella* on tea towels and cloths collected 6/2/17
  - EH 4th inspection
  - Samples collected - tea towels & chux
- **9 new cases of *Salmonella* received - 6 reported eating at cafe**
  - 5th EH inspection - swabbing and tea towel and chux collected for sampling
- **5 new notifications of *Salmonella* - 2 linked to case exp. 10/2/17**
  - EH Issues PO and carry out closure.

**List of Abbreviations**
- HPS: Health Protection Service
- EH: Environmental Health
- CDC: Communicable Disease Control Section
- PO: Prohibition Order
- CI: Confidence interval

**Timeline Events**
- CDC on-call notified of 15 *Salmonella* positive by TCH microbiology
- Interim case control analysis of 22 cases & 22 controls reported mango or berry smoothies OR 441 (CI 4 - 1625)
- 23 new cases of *Salmonella* received between 7/2 and 10/2
  - Case-control ceased
Chapter 5

Evaluation of Varicella Zoster Virus (VZV) surveillance in the Australian Capital Territory
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Prologue

Role

Varicella-zoster virus (VZV) became notifiable in the ACT in 2006, following the introduction of varicella vaccine to the National Immunisation Program (NIP) in November 2005. In 2016, herpes zoster vaccine was added to the NIP for adults aged 70 years, with catch-up dose funded for those aged 71–79 years until late 2021. Notification data is valuable in the assessment of vaccine impact. I was tasked with formally evaluating the surveillance of VZV in the ACT as an aspect of the broader notifiable disease surveillance system in the territory. I was responsible for conducting literature review, formulating the evaluation plan, developing evaluation tools, and engaging stakeholders. I analysed data from the ACT Notifiable Disease Management System (NDMS), the National Notifiable Disease Surveillance System (NNDSS) and developed stakeholder surveys. The evaluation culminated in a brief report of key findings and recommendations submitted to ACT Health and feedback to stakeholders that participated in the evaluation.

Lessons learnt

I had not previously been involved in a formal evaluation project of a public health surveillance system. During the project I learnt a number of important skills:

Firstly, the importance of setting project objectives that are specific, measurable, achievable, realistic and time-based (SMART). Surveillance of communicable diseases is complex and focused objectives are required to produce usable outcomes.

Secondly, I learnt how to implement and adapt a structured framework for evaluation – the US Centre for Disease Control and Preventions’ *Updated Guidelines for evaluating public health surveillance systems* – to the specific requirements of the system being evaluated. In doing so, I gained experience in identifying and engaging with stakeholders, and learnt that buy-in is an important aspect of successful evaluation.

Finally, I learnt that surveillance systems for notifiable conditions have limitations, particularly underestimating disease incidence and I gained an in-depth comprehension of how surveillance systems work, and their usefulness.
Implications for public health
The findings from this evaluation have resulted in the development of recommendations to the CDC section at ACT Health. Recommendations made are directed at improving capability of the system to meet its objectives, and to increase the efficiency of which the system operates. A summary of the evaluation findings will be generated to be distributed to general practitioners through the Capital Health Network with the aim of increasing awareness of VZV surveillance in the ACT and informing of the changes to the surveillance process.

Acknowledgments
I think it may be inevitable that from the time you start an evaluation project to the time you finish the number of people you wish to acknowledge grows exponentially. I would like to thank the following people for their assistance and involvement in this project

My academic and workplace supervisors; Dr Aparna Lal, Ms Rebecca Hundy and Dr Marlena Kaczmarek for the guidance, assistance, patience and expertise throughout this project.

All the staff from the Communicable Disease Control Section at ACT Health, Sue Reid, Rachel Crane, Milica Stefanovic, Michelle Boxx, Jodie Huet, Carolyn Banks, Ashleigh Keeling, Miranda Harris, and Vanessa Johnston for participating in the evaluation and answering any questions regarding the system. And also for their continued support and friendship throughout by MAE placement.

I want to acknowledge Jennifer Ridgeway and Lynette Chairuka of ACT Pathology for sharing with me their expertise, and answering any question.

Roz Lemon at Capital Health Network for her invaluable help in engaging with the ACT Pathology general practice community and all the General Practitioners who supported the evaluation through their involvement in the survey.

Master of Philosophy (Applied Epidemiology) core requirement
This chapter is included in my bound volume to fulfil the Master of Philosophy (Applied Epidemiology) requirement of: Evaluate or establish a public health surveillance system.
Ethics

Ethics was not sought for the project as per the ACT Health Research Ethics and Governance Office policy on the requirements for ethical review relating to Quality Improvement/Quality Assurance (QI/QA) and Evaluation projects. Available:
Evaluation of varicella-zoster virus surveillance in the Australian Capital Territory

Abstract

Background

The Communicable Disease Control Section (CDCS) has conducted surveillance of VZV since it became notifiable in the ACT in 2006. An evaluation of the surveillance system for VZV was conducted to measure the performance of surveillance against the system objectives and purpose.

Methods

The Australian Capital Territory VZV surveillance system was evaluated using the US Centers for Disease Control and Preventions’ *Updated Guidelines for evaluating public health surveillance systems*. The objective, purpose and operation of the system was described by reviewing relevant documents. System attributes defined in the guidelines were assessed using: data extracted from the ACT Notifiable Disease Management System and the National Notifiable Disease Surveillance System. Rates were calculated using ABS estimated resident population estimates and data were described against the relevant system attributes. User perspectives of the system’s performance against attributes were elicited through surveying internal stakeholders (CDCS and pathology staff) and external stakeholders (general practitioners).

Results

The evaluation found that although lacking defined objectives, the VZV surveillance system in the ACT performed questionably against objectives identified in the document review and against the perceived objectives of users. The usefulness of the system to measure vaccine impact is generally poor, yet data produced by the system is comparable to other states and territories. The ability of the system to monitor disease trends was found to be limited by low sensitivity and representativeness, in part due to problems with simplicity, data quality, and acceptability. The system fails to capture enough data to consistently and accurately characterise case by disease type.
Overall attributes of the system were perceived differently by end users (CDCS) and contributors (GPs). The system is reliant on laboratory notification which affects data quality, sensitivity, timeliness, and representativeness – however the predictive value should be high considering the specificity of laboratory tests. In turn, the reliance on laboratory notifications is likely driven by complexity within the system and issues with flexibility of the data base on which the system operates and the overall acceptability of the system by contributors.

**Conclusion**

A number of recommendations from the evaluation are provided. Notably measures around improving case ascertainment and characterisation are important considerations if surveillance of VZV in the ACT is going to be useful moving forward.
Introduction

Varicella-zoster virus

Varicella-zoster virus (VZV) is a member of the *Herpesviridae* family that consists of eight herpesviruses known to cause disease in humans.\(^1\) VZV is the cause of both varicella (chickenpox) and herpes zoster (shingles) disease.\(^2\) Varicella is the manifestation of primary infection with VZV after which the virus establishes latency in neuronal cells persisting in sensory nerve dorsal root ganglia, and herpes zoster results from reactivation of latent virus.\(^3\)

Pathogenesis

Person-to-person transmission of varicella occurs via droplets or aerosols from respiratory secretions or direct contact with vesicle fluid from skin lesions.\(^4\,6\) Varicella cases are infectious from 1–2 days prior to onset of rash until all skin lesions have scabbed (usually 5–7 days).\(^4\,6\) Herpes zoster is less contagious due localised vesicle eruption, however direct transmission may occur through environmental contamination with VZV DNA, or direct contact with lesion fluid.\(^7\) The entry point of the virus in susceptible hosts is thought to be the mucosal surfaces of the respiratory tract.\(^8\) The incubation period is commonly 14–16 days (range 10–21 days).\(^1,4,8\) Following primary infection with VZV, reactivation of the virus causing herpes zoster has been shown to be affected by waning cell-mediated immunity.\(^1,8,9\)

Clinical Features

Varicella typically affects young children and is characterised by onset of low-grade fever, concurrent with a generalised, pruritic, vesicular rash, and commonly associated with malaise, headache, and loss of appetite or feeding difficulties.\(^1,4,8,9\) Lesions are small and typically numbering 250–500 at varying stages of disease development, starting out as maculopapular at initial onset before becoming vesicular and pustular for 3–4 days after which they crust leaving granular scabs which fall off after 1–2 weeks.\(^4,8\) Primary infection with varicella in adults may present with a prodrome of fever and malaise 1–2 days prior to onset of rash.\(^1\)

Wild-type varicella in previously immunised individuals with onset greater than 42 days after vaccination are defined as breakthrough (vaccine failure) cases. Breakthrough cases
generally present with more mild illness; reduced or no fever, and fewer than 50 lesions which do not progress to vesicles and carriers a lower risk of complication.\textsuperscript{9}

Complications associated with varicella can be bacteria mediated causing secondary infection and pneumonia.\textsuperscript{10} Rare but severe complications of the central nervous system include benign cerebral ataxia, encephalitis, meningitis, transverse myelitis.\textsuperscript{9} Of particular concern is infection in pregnant women, in which intrauterine transmission may cause congenital varicella syndrome which is characterised by severe birth abnormalities with poor prognosis.\textsuperscript{1}

Herpes zoster is characterised by 2–3 days of localised pain restricted to the dermatome corresponding to the single or associated group of dorsal root ganglia where reactivation of latent VZV occurs.\textsuperscript{4} Pain precedes the eruption of unilateral vesicular rash in the affected area.\textsuperscript{5} Vesicles continue to form over the next 3–5 days, and heal within 2–4 weeks.\textsuperscript{4, 11} The most frequent complication associated with herpes zoster is chronic severe pain from postherpetic neuralgia (PHN), that can last for extended periods of time and severely debilitate quality of life.\textsuperscript{1} Non-pain complications in herpes zoster patients are less common and include cranial-nerve palsies, myelitis, herpes zoster ophthalmicus and contralateral hemiplegia.\textsuperscript{11}

**Diagnosis**

Clinical diagnosis of varicella is made primarily on the existence of the characteristic vesicular rash, and can be further supported by evidence of recent exposure to another case.\textsuperscript{8, 12} Similarly, diagnosis of herpes zoster is commonly made on clinical grounds, observing the characteristic rash and associated pain.\textsuperscript{8}

To confirm diagnosis, pathology testing is available when a clinical specimen can be collected. Skin lesion swabs are the primary specimen collected for testing. Methods include: polymerase chain reaction (PCR) to detect viral DNA, serological testing of Immunoglobulin IgG, IgM antibodies using enzyme linked immune sorbent assay (ELISA), antigen detection using immunofluorescence and culturing the virus. PCR testing is the most sensitive and specific pathology test available to confirm diagnosis.\textsuperscript{12}
Treatment and Public health management

There is no specific treatment for varicella, notwithstanding symptomatic management, and in almost all cases illness is self-limiting. In instances where there is increased risk of severe disease – immunocompromised, or neonates whose mother acquired infection around the time of delivery – antiviral treatment can be given within three days of onset.\textsuperscript{8,13} For herpes zoster cases, antiviral therapy, also given within three days of onset, can reduce severity and duration of illness, and may reduce the risk of PHN.\textsuperscript{9,14}

Public health management of VZV cases primarily concerns the identification of susceptible and high risk contacts. Post-exposure prophylactic varicella vaccine can be administered to non-immune age-eligible children and adults following exposure to varicella or herpes zoster; and should be administered within five days (preferably three) following exposure. Post exposure vaccination has been shown to be an effective measure for outbreak control.\textsuperscript{15} Passive immunisation with varicella zoster immunoglobulin (ZIG) can sometimes prevent, and more usually reduces severity of illness amongst exposed contacts who are at high risk of severe disease.\textsuperscript{9} ZIG should be administered within 96 hours of exposure (there is some evidence for efficacy up to 10 days).\textsuperscript{9}

Vaccine

Varicella vaccine was first developed in 1974. All available vaccines are derived from the Oka VZV strain with some genetic difference.\textsuperscript{9,16} In 2003, a single-dose of varicella vaccine for all non-immune infants aged 18 months, and a single catch-up dose for 10–13 year olds with no history of vaccination or clinical disease was recommended by the Australian Technical Advisory Group on Immunisation (ATAGI), but not funded. Inclusion onto the NIP commenced in November 2005, as a single dose at 18 months; with a school-based catch-up dose for adolescents 10–13 routinely offered from 2006.\textsuperscript{9}

Australian national vaccination coverage measured in 2007 at 24 month of age was 78.4%, (range 75.8%, WA–81.8%, QLD) and by 2012 uptake had increased to 84.4% (range 81.8%, WA–88.9%, ACT).\textsuperscript{17,18} In mid-2013 a quadrivalent combination vaccine contain measles, mumps, rubella and varicella (MMRV) replaced the monovalent vaccine on the NIP for children aged 18 months.\textsuperscript{19} Subsequently observed coverage assessed in 2014 at 24 months increased to 89.6% nationally (range 87.7%, WA– 92.3%, ACT).\textsuperscript{19} Recent randomized control trial evidence from the United States suggest the use a two-dose schedule minimizes
the risk of breakthrough disease.\textsuperscript{20} A two-dose schedule is recommended in Australia, but currently not funded.

Herpes zoster vaccine, Zostavax\textsuperscript{©}, is a live attenuated vaccine formulated from the same VZV strain as the Varivax\textsuperscript{©} varicella vaccine, but of higher potency.\textsuperscript{9} Large randomized control trials have demonstrated that the vaccine significantly reduced the likelihood of developing herpes zoster and PHN, with varying efficacy by age.\textsuperscript{14,21,22} A vaccine for herpes zoster was registered in Australia in 2005, however was not readily available until becoming commencing on the NIP in November 2016 as The National Herpes zoster Vaccination Program.\textsuperscript{23} Although vaccination is recommended for people 60 years and older, under the NIP Zostavax\textsuperscript{©} is funded for all adults 70 years of age from November 2016, with a catch-up program funded until 2021 for adults aged 71–79 years.\textsuperscript{23} Given the extended period which VZV infection has been nationally notifiable, pre- and post-vaccine notification surveillance data could be used in vaccine effectiveness analysis for herpes zoster. This is an important motivation for assuring that quality surveillance data is available.

**Epidemiology and Impact of vaccine**

In temperate climates varicella is ubiquitous in unimmunised populations where annual case numbers approximate the birth cohort,\textsuperscript{24} with more than 90\% of people infected prior to adolescence.\textsuperscript{8} In tropical regions the proportion of cases is higher in adults.\textsuperscript{8,9} Herpes zoster occurs most commonly in people of older ages, with the lifetime incidence rate estimated to be 10\%–30\% in the general population and 50\% in the population who live to 85 years.\textsuperscript{9,25,26} Complication is relatively common, and risk increases with age and being immunocompromised.\textsuperscript{4} PHN occurs in approximately 20\% of cases in those aged >80 years, and 10\% of cases in those aged 50–59 years.\textsuperscript{9}

Prior to the introduction of a varicella vaccination program in Australia, the annual incidence of varicella infections approximated a birth cohort (~250,000 people).\textsuperscript{27} Primary infection occurred most frequently in childhood, 83\%, by 14 years of age.\textsuperscript{28} Annually there were 1500 hospitalisations, with rates highest in children under 5 years, and an average of 7 to 8 deaths each year.\textsuperscript{29,31} After the inclusion of varicella vaccine to the NIP a 69\% decline in hospitalisations was observed in children aged 1.5–4 years in the first two-and-a-half years.\textsuperscript{32} The greatest decline observed in 0–4 year olds.\textsuperscript{9} Reduced hospitalisations have been
attributed to the effects of herd immunity.\textsuperscript{33} There has also been a significant reduction in severe outcomes of varicella including, congenital and neonatal varicella.\textsuperscript{34}

Concern about breakthrough varicella, disease burden shifting to older age groups and potential increases in herpes zoster has seen some countries, mainly European, forego population-based varicella vaccination programs.\textsuperscript{33,35} Modelling of the impact of population-based vaccine programs has predicted a potential increase in herpes zoster incidence, based on the assumption exposure to circulating wild-type VZV boosts immunity.\textsuperscript{36} In the US varicella vaccination was introduced in 1995 and to date there is no evidence which demonstrates substantially altered herpes zoster incidence in the wake of population-based vaccination.\textsuperscript{9,37,38} In Australia, increasing incidence of herpes zoster has been reported both before and after the introduction of varicella vaccine where data is available.\textsuperscript{39,40} In the pre-vaccine era increases in herpes zoster GP consultation rates over time have been considered likely due to the ageing of the population.\textsuperscript{40} Whilst, a comparison of hospitalisations for herpes zoster both pre- and post-vaccine revealed no change in age-adjusted and age-specific hospitalisation rates in the in the five years following varicella vaccine introduction, despite high vaccine uptake.\textsuperscript{33} The use of herpes zoster vaccination has not been used long enough in any country to demonstrate impact on disease epidemiology. The existence of surveillance data prior to commencing herpes zoster vaccination programs in Australia is another impetus for quality surveillance.

**Rationale for Evaluation**

In the ACT VZV has been on the notifiable condition list since 2006. Routine surveillance is conducted as part of the notifiable disease surveillance system in the ACT. Previously, surveillance of VZV infection by the system has not been evaluated.


**Evaluation framework**

The framework used in this evaluation has been adapted from the US Centre for Disease Control and Preventions’ *Updated Guidelines for evaluating public health surveillance systems*, henceforth referred to as the *CDC guidelines*. 41

**Aims and objectives**

To undertake a qualitative and quantitative evaluation of the VZV surveillance system in the ACT. And, in doing so, to determine whether the VZV notification surveillance system is achieving the objectives set of the system.

The objectives of the evaluation were to:

1. Describe the operation of the surveillance system
2. Describe the epidemiology of VZV notifications in the ACT by person, place and time
3. Compare ACT notification trends to other states and territories
4. Engage stakeholders and assess their perspectives
   - Internal stakeholders through surveys and discussion (focus) groups
   - External stakeholders through surveys of attitudes and practices towards the surveillance system
5. Assess the attributes of the surveillance system as defined by the *CDC guidelines*
6. Identify areas for improvement and make recommendations

**Methods**

**Surveillance system purpose, objectives and operation**

The purpose, objectives and operation of the surveillance system were assessed by informally reviewing documentation relating to the system’s operation. Documents reviewed included: past and current SOPs, guidelines and protocols, past and current ACT Notifiable Condition Code of Practice, National Case Definitions, and past Chief Health Officer Annual Reports. The operation of the system was then described with regards to the legislation the system acts under, case definitions, data flow (notification process), quality improvement processes and resources the system requires.
Stakeholder Consultations

Internal

An electronic self-administered survey was designed using SurveyMonkey® to gather internal stakeholder perspectives of the perceived objectives of the system, the system's performance against these objectives and views on system performance with respect to each of the system attributes defined by the CDC guidelines.

Internal stakeholders were defined as members of the ACT Health, Communicable Disease Control section (CDCS) who either: directly used the system, would be actively involved in acute public health responses relating to VZV, or have a vested interest in the data produced by the system. In order to clarify survey responses a discussion (focus) group was conducted with all participants to expound on common themes identified in primary analysis of survey responses. A modified version of the questionnaire was made available for a representative of the public pathology laboratory, and follow up discussion was conducted to determine testing procedures, test sensitivity and specificity and changes in laboratory practices over time.

In addition, informal discussions with the CDC team responsible for the data entry, surveillance management and public health response were conducted to clarify surveillance processes.

External - General practice survey

As primary health care providers to the community, General Practitioners (GPs) were considered as external stakeholders. An electronic self-administered survey was designed using on SurveyMonkey® to collect information on GP interaction with the surveillance system. The survey was advertised in the Capital Health Network 2/52 Health Care Bulletin to GPs attached with a link to complete the survey online. In order to maximise response rates, GPs were followed up with an email containing a letter from the Chief Health Officer, also with a link to the survey in addition to a pdf version of the survey to allow responses by post or fax. The questionnaire allowed GPs to remain anonymous.

Descriptive analysis of the internal and GP stakeholder survey responses was conducted in Microsoft Excel (Microsoft, USA).
Data analysis of surveillance data

The Notifiable Disease Management System (NDMS) is the ACT Health database for communicable disease notifications. All VZV notifications for varicella and herpes zoster, with an onset date from 01 January 2006 to 31 December 2016, were extracted from the NDMS database. Unspecified confirmed and ‘not meeting public health criteria’ (NMPHC) records for the outlined dates were also extracted. Notifications NMPHC are defined as cases whose residence is outside the ACT or notifications which do not meet the probable case definition as per the national case definitions (Box 1). Cases classified as NMPHC are not included in analysis unless otherwise specified.

National Notifiable Disease Surveillance System (NNDSS) data for varicella, herpes zoster and VZV unspecified were obtained from the NNDSS database for the following fields: State (NT, QLD, SA, Tas, Vic, WA), Diagnosis year, month, age group (5–year), and sex.

Age specific notification rates were calculated using population estimates obtained for age-specific mid-year estimated resident population for years 2006–2016 available from the Australian Bureau of Statistics (ABS) (Catalogue 3101.0, published 15/12/2016).

Descriptive data analysis for both datasets was conducted in Stata IC v14 (StataCorp LP, College Station, TX, USA) and Microsoft Excel. Details of the analysis of surveillance data are provided in the relevant attributes section below.

Assessment of surveillance system attributes

Usefulness

The level of usefulness of a surveillance system is the measure of the system’s contribution to the prevention and control of adverse health-related events under surveillance, including improving understanding the public health implications of such events e.g. being able to observe the effect of vaccination policy in populations.

To measure usefulness the system’s performance towards meeting its stated purpose and objectives (identified in the document review) was assessed. To demonstrate the performance of the surveillance system the epidemiology of varicella notifications in the ACT were described and compared with other states and territories. Crude and age-specific notification counts and rates were calculated for ACT NDMS data by each disease.
Chapter 5

classification to determine visible trends over time in the data. Notification rates for the ACT were compared against notification rates nationally, by state or territory.

To assess the perceived usefulness of the system, the internal stakeholder survey asked participants to rank a list of objectives in order of importance. The list was generated in consultation with the CDCS surveillance manager in lieu of limited objectives identified in the document review. Participants were asked how the system performed against their ranked objectives. To assess perceived usefulness by GPs, the survey asked if participants found the surveillance system useful, and if not, why?

**Simplicity**

Simplicity refers to the structure of the system and its ease of operation. The description of the surveillance system details the notification requirements of clinicians, pathology laboratories and the notification process. Stakeholder surveys measured simplicity using a Likert scale to ask participants about ease of notifying and ease of completing all notification fields.

Counts of cases over the period 2006–2016 by disease type, confirmation status and notifier were extracted from the NDMS to contextualise the stakeholder responses and the system operation in terms of simplicity.

**Flexibility**

Flexibility of a public health surveillance system is the capacity to adapt to changing information needs or operating conditions with limited additional time, personnel or allocated funds. The flexibility of the ACT VZV surveillance system was measured by internal stakeholder surveys and follow-up interviews. Responses to questions regarding the flexibility of the system were measured using a Likert scale.

Between 2006 and 2016 there have been several changes to the surveillance infrastructure. In lieu of formal documentation and logs, discussions with CDCS staff elucidated major events which may have impacted the surveillance of VZV and how the system responded to any changes.

**Data quality**

Data quality reflects the completeness and validity of the data recorded by the surveillance system. To assess data quality NDMS data was assessed by the proportion of cases...
Evaluation

classified as varicella or herpes zoster and for completeness. Fields analysed for completeness were: confirmation status, date of onset of illness, vaccination status and indigenous status.

The data quality of the ACT VZV surveillance system was also measured in internal stakeholder surveys and follow-up discussion. Responses were measured using a Likert scale to questions regarding the data quality of the system.

**Acceptability**

The acceptability of a surveillance system reflects the willingness of persons and organisations to participate in surveillance. The acceptability of VZV surveillance in the ACT was measured through stakeholder surveys. Internal stakeholder surveys asked questions relating to acceptability and measured responses using a Likert scale. Similarly, the external stakeholder GP survey used a Likert scale but measured responses to questions regarding notification practices as a proxy for acceptability.

**Sensitivity**

Sensitivity of a surveillance system can be understood as the proportion of cases detected by the system, and also can refer to the ability of the system to detect outbreaks. To assess the sensitivity of case ascertainment by the system a representative from the public pathology laboratory was asked to comment on the sensitivity of current laboratory tests.

Without any know estimates of the prevalence of varicella cases in the post vaccine era, or of herpes zoster cases in the community it is difficult to estimate the sensitivity of the surveillance system. Describing the pathway by which notifications are made was used to identify inherent features of the system where sensitivity may be affected.

Notification rates were compared between the ACT and SA, where the low proportion of unspecified cases reported by SA makes the state’s data a ‘gold standard’ of VZV notification data. ACT notification rates were also compared by notifier to explore the effects of the notification pathway described.

**Predictive value positive**

Predictive value positive (PVP) is the proportion of reported cases that actually have the health related event under surveillance. In an operational context PVP is an indicator of system efficiency. A low PVP for example may indicate unnecessary public health action is
being conducted. PVP was not calculated due to limitations of the NDMS. To consider factors that may affect PVP notifications were examined by laboratory diagnostic method in the context of test sensitivity and specificity. The proportion of clinical notifications (probable cases) from total number of cases was calculated by year to see if there had been any change over time and to contextualise responses from the GP survey.

**Representativeness**
Representativeness refers to how accurately the system describes a representative understanding of occurrence of the health related event over time in its distribution in the population by person and place.\(^{41}\) The representativeness of the ACT VZV surveillance system was assessed in internal stakeholder surveys and follow-up discussion. Responses were measured using a Likert scale to questions regarding the flexibility of the system.

**Timeliness**
Timeliness reflects the speed between steps in a public health surveillance system.\(^{41}\) The date of onset and date of notification were considered as key steps in the system and the time between these dates was calculated to determine timeliness. Responses to internal stakeholder surveys were measured using a Likert scale to questions regarding the timeliness of the system.

**Stability**
Stability refers to the reliability, and availability of the system.\(^{41}\) Stability was determined through internal stakeholder survey and follow-up discussion.
Evaluation outcomes

Surveillance system purpose, objectives and operation

Purpose and objectives

The objective of the VZV notification surveillance system is not formally documented in the CDCS shared network drive where documentation for disease specific guidelines, factsheets, SOPs, outbreak files, and work plans and duties are stored. However, a 2006 draft ‘ACT Health Protocol for the public health management of varicella’, last revised in September 2010, details the “objectives of varicella surveillance and recording vaccination status”. The documents states:

“The primary objective is to monitor the impact of the national varicella immunisation campaign (this was agreed to at the national level in late 2005)”

and;

‘Therefore, the ACT’s surveillance program is aimed primarily at ‘counting cases’

No other formal or informal documentation defining objectives were identified. Discussions with the CDCS manager led to the generation of a list of ‘informal’ (undocumented) objectives of the system that in practice define what purposes the system could potentially be used for. This list was used, in conjunction with documented objectives identified above, in internal stakeholder surveys to elucidate the perceived objectives of the system presented in the evaluation findings section (Figure 10).

Operation

Legislation


Under both the CoP 2006 and CoP 2017, medical practitioners and authorised nurse practitioners, pathologists, hospitals, and responsible people are obligated to notify the Chief Health Officer (CHO) in accordance with the relevant provision of the Public Health

In both codes delegation to receive notification is given by the CHO to public health officers within the CDCS of the Health Protection Service (HPS).

In the CoP 2017, notification time frames are associated with groups of notifiable conditions. In the code, varicella is classified as group B notification which requires notification within five days of diagnosis. Case definitions are not specifically prescribed in the code, instead the code refers case definition to the CDCS at HPS.

**Case definition**

VZV surveillance in the ACT utilises the national surveillance case definitions for Varicella-zoster infection (varicella), Varicella-zoster infection (herpes zoster) and Varicella-zoster infection (not elsewhere classified) – referred to here as unspecified. National case definitions were initially defined and endorsed by the Communicable Disease Network Australia (CDNA) in 2006, and last reviewed in 2008 when no change was made. The national case definitions are shown in Box 1.

Document review of current draft and final protocols, guidelines or SOPs identified in the CDC section shared network drive, confirmed consistent use of the national case definitions from 2006 to 2016.

In January 2017, the case definition for Varicella-zoster infection (not elsewhere classified) was changed to remove the wording ‘from a skin or lesion swab’ from relevant criteria to broaden the types of laboratory specimens that can be tested. Analysis of 2017 data was outside the scope of this evaluation.
Box 1: National case definitions

Varicella-zoster infection (chickenpox)

**Confirmed case**
A confirmed case requires either:

1. Laboratory confirmed evidence AND clinical evidence
   OR
2. Clinical evidence and epidemiological evidence

**Laboratory definitive evidence**

1. Isolation of varicella-zoster virus from a skin or lesion swab or detection of varicella-zoster virus from a skin or lesion swab by nucleic acid testing or direct fluorescent antibody. If the case received varicella vaccine between five and 42 days prior to the onset of rash the virus must be confirmed to be a wild type strain.
   OR
2. Detection of varicella-zoster virus-specific IgM in an unvaccinated person.

**Clinical evidence**
Acute onset of a diffuse maculopapular rash developing into vesicles within 24–48 hours and forming crusts (or crusting over) within 5 days.

**Epidemiological evidence**
An epidemiological link is established when there is:

1. Contact between two people involving a plausible mode of transmission at a time when:
   a. One of them is likely to be infectious
   AND
   b. The other has illness 10 to 21 days after contact
   AND
2. At least one case in the chain of epidemiologically linked cases is laboratory confirmed.

**Probable case**
A probable case requires clinical evidence only.
Varicella-zoster infection (shingles)

**Confirmed case**
A confirmed case requires laboratory confirmed evidence AND clinical evidence.

**Laboratory definitive evidence:**
1. Isolation of varicella-zoster virus from a skin lesion or swab.
   OR
2. Detection of varicella-zoster virus from a skin lesion or swab by nucleic acid testing from a skin lesion or swab.
   OR
3. Detection of varicella-zoster virus antigen from a skin lesion swab by direct fluorescent antibody from a skin or lesion swab.

**Clinical evidence**
A vesicular skin rash with a dermatomal distribution that may be associated with pain in skin areas supplied by sensory nerves of the dorsal root ganglia.

**Probable case**
A probable case requires clinical evidence only.

Varicella zoster infection (not elsewhere classified)

**Confirmed case**
A confirmed case requires definitive evidence, either in the absence of clinical information or where clinical evidence does not meet criteria for varicella-zoster infection (chickenpox) or varicella-zoster infection (shingles).

**Laboratory definitive evidence**
1. Isolation of varicella-zoster virus from a skin or lesion swab or detection of varicella-zoster virus from a skin or lesion swab by nucleic acid testing or direct fluorescent antibody. If the case received varicella vaccine between five and 42 days prior to the onset of rash the virus must be confirmed to be a wild type strain.
   OR
2. Detection of varicella-zoster virus-specific IgM in an unvaccinated person.
Figure 1: Flow chart of VZV notification surveillance in the ACT

Data flow (notification)

The notification process for VZV in the ACT is summarised in Figure 1. The VZV notification surveillance system in the ACT aims to capture the whole population of the territory. Notification of a case begins with the presentation of a case to health services. There are three main primary care services potentially available to VZV cases are: General practice, hospitals and nurse practitioner led walk-in-centres.

The national case definition for Varicella-zoster infection states confirmed and probable cases should be notified. The national case definition for varicella-zoster infection (not elsewhere classified) states only confirmed cases should be notified. As the probable case definition for varicella or herpes zoster requires only clinical evidence of infection, medical practitioners that clinically diagnose cases should, under the CoP 2006 and 2017, notify the
CDCS. Notification can be made by posting or faxing a completed *Report of Notifiable Condition or Related Death Form* within five days of diagnosis. Alternatively, a medical practitioner may complete a notification from with CDCS surveillance officers or public health nurses on the phone. If vaccination status is not provided in the notification it is obtained from the Australian Immunisation Register by surveillance officers when possible.

The ACT Health walk-in-centres provide free one-off advice and treatment for people with minor illness and injury. The centres are staffed by registered nurses and nurse practitioners and lack the capacity to swab patients for laboratory testing. Under the current CoP the on-duty nurse-practitioner at the walk-in-centre should notify the CDCS of a clinically diagnosed probable case of VZV. Walk-in-centres can notify using a notification form by fax, post or telephone directly to CDCS.

Case presentation to a medical practitioner may result in a specimen, from a skin or lesion swab, being taken to be forwarded to a pathology laboratory for testing. If a positive test is returned, the pathology laboratory will forward the result to the requesting doctor and also to the CDCS via automated fax. This constitutes a formal notification from the pathology laboratory.

All laboratories collect a minimum dataset of first and last names, date of birth, sex, referring doctor, and clinical notes. Confirmation of clinical presentation (varicella or herpes zoster) is defined by clinical notes, if present. The three laboratories that are primarily used by ACT clinicians for VZV testing have automated systems that confer notification of positive results to the CDCS by fax.

Medical and laboratory notifications received by the CDC section by any means are entered into the Notifiable Disease Management System (NDMS) by either the surveillance officer or a public health nurse. The NDMS is a person-centric data base. This means when a person is first notified of any disease a case file is created for that person. Disease specific notifications are then attached to that person file. One person may therefore have multiple notifications for each new infection of a notifiable condition. A notification in the system consists of information from both laboratory notification and the medical notification form, where available.
On reception of either a medical or laboratory notification the surveillance officer or public health nurse will search the NDMS by name and date of birth to identify if a notification (laboratory or medical) has already been received and entered into the system. The process limits the potential for duplication of case records. The NDMS only allows one form of notification to be entered and by practice it is the first notification received (laboratory or medical) that is entered into the system. This is a major limitation of the system. The surveillance officer or public health nurse will classify the case based on information available from either or both a laboratory and medical notification. If there is no indication of a clinical presentation or suspicion of either varicella or herpes zoster, the case is entered as VZV unspecified into the database.

Required reporting fields not routinely reported on laboratory notifications may be cross-referenced with other ACT Health databases and national databases. To determine indigenous status Clinical Portal (ACT Hospitalisation records) and ACTPAS (ACT Patient Administration System) is searched by name and date of birth. To identify vaccination status for appropriate aged cases the Australian Immunisation Register (AIR) is reviewed. A summary of the data entry process is presented in Figure 2.

At the time of writing, the CDC section conducts fortnightly surveillance data reviews of all notifiable disease reported year-to-date. Case counts of varicella, herpes zoster and VZV unspecified and the ratio of observed cases compared to the five-year mean is presented. Long-term descriptive epidemiological analysis are conducted sporadically. Discussion on aspects of the surveillance system and investigation occurs formally in fortnightly ‘non-data surveillance meetings’ which focuses on the operation of surveillance for all diseases and investigation procedures.
Data quality improvement

There is no established practice for routine data quality improvement processes. Instead data cleaning is tied to data reporting requirements to the Commonwealth Department of Health, NNDSS. Data transfer from the NDMS to the NNDSS occurs through the Data Acquisition System (DAS) at the Commonwealth on a daily basis. Annual data validation requests from the NNDSS guide data cleaning in the NDMS dataset.

Resources used

VZV surveillance data is recorded in the NDMS and requires no additional resources for data storage. Data management of the surveillance system is the responsibility of CDCS staff. Internal stakeholder interviews identified that amongst staff that are actively involved in data management of the system (5/9 responses) most staff either ‘strongly agreed’ (3/5 responses) or ‘agreed’ (1/5 responses) that “time spent on VZV surveillance is worth my time”.

Figure 2: Laboratory notification data entry process
Surveillance system attributes

Usefulness

Notification of VZV in the ACT

There were 2,346 confirmed or probable notifications of VZV to ACT Health with an onset between 01 January 2006 and 31 December 2016. Of these, 332 cases were specified as varicella (14.15% of confirmed or probable cases), 738 cases were specified as herpes zoster (31.46% of confirmed or probable cases) and 1,276 cases were unspecified (54.39% of confirmed or probable cases). The number VZV notifications for all disease classifications has appeared to as increased over time (Figure 3).

![Figure 3: Notification counts of varicella, herpes zoster and VZV unspecified by month and year, ACT, 2006–2016](image)

The number and rate of varicella notifications was highest the children younger than 10 years (Figure 4). The varicella notification and rate was slightly higher in females (n=186; 101 per 100,000) than males (n=146; 80 per 100,000). The counts and rates of varicella notifications decrease dramatically between the 5–9 year age group, 10–14 year age groups (around the beginning of adolescence) and the 15–19 year age group (Figure 4). There is an increase in the count of notifications in 20–49 year olds, however age specific varicella notification rates decrease with age (Figure 4). The number of herpes zoster notifications
peaked in those age 60–69 years for both males and females, despite the rate of notification peaking later at ages ≥80 years for males and 70–79 years for females (Figure 5). There is a sharp increase in herpes zoster notification counts between the 15–19 year age group and the 20–29 year age group and notification rates show an increase in notifications with age (Figure 5). The herpes zoster notification and rate was slightly higher in males (n=420; 230 per 100,000) than females (n=317; 171 per 100,000).

Counts of VZV unspecified notifications were higher in younger age groups, those aged 0-59 years (Figure 6) compared to herpes zoster notification cases (Figure 5). Similar to herpes zoster notification counts (Figure 5) there is a sharp increase in the count of VZV unspecified notifications, where an increase in the rate of notifications is not observed. The herpes zoster notification and rate was slightly higher in males (n=690; 377 per 100,000) than females (n=585; 316 per 100,000).

Figure 4: Total notification count and average annual notification rate per 100,000 population of varicella, by age and sex, ACT, 2006–2016
Figure 5: Total notification count and average annual notification rate per 100,000 population of herpes zoster, by age and sex, ACT, 2006–2016

Figure 6: Total notification count and average annual notification rate per 100,000 population of VZV unspecified, by age and sex, ACT, 2006–2016
NNDSS

Varicella notification rates for the ACT increased over time, most dramatically from 2013. Nationally trends differed (Figure 7). Rates of varicella in the ACT were lower compared to most other states and territories prior to 2013. Post 2013, ACT rates are higher than Tasmania and Queensland and the national average. In 2016, ACT rates peaked, on par or higher than Victoria, Western Australia and South Australia (SA). In SA, VZV has been notifiable since 2002, and the low proportion of unspecified cases reported by the state makes SA data the gold standard of VZV notification data in the country.

![Graph displaying notification rate per 100,000 population of varicella, Australia, 2006 by state and territory.](image)

**Figure 7: Notification rate per 100,000 population of varicella, Australia, 2006 by state and territory**

The notification rates of herpes zoster and unspecified notification rates has increased around the country, with the exception of Queensland (Figure 8). Herpes zoster notification rates in the ACT were lower than most states and territories prior to 2013, similar to varicella (Figure 8). Rates of unspecified cases are similar to herpes zoster. Unspecified rates are lowest in SA, the Northern Territory (NT) and Tasmania. The ACT performs worse than these states and territories (Figure 9). VZV unspecified rates were higher than
rates for varicella and herpes zoster in all years except 2015 and 2016 (Figure 9).

Figure 8: Notification rate per 100,000 population of herpes zoster, Australia, 2006 by state and territory

Figure 9: Notification rate of varicella zoster (unspecified) per 100,000 population, Australia, 2006 by state and territory
Stakeholder consultation

Internal

The internal stakeholder assessment of CDC staff asked for a priority ranking of a list of potential surveillance system objectives (Figure 10).

![Figure 10: Average ranking of internal stakeholders priority ranking of the objectives of the VZV surveillance system.](image)

The highest ranking objectives of the system amongst internal CDC stakeholders were to “Detect and monitor disease trends”; and to “Detect persons at high risk and inform appropriate public health follow-up”. Detecting and monitoring disease trends is synonymous with the objective of ‘counting cases’ listed in the 2006 draft protocol. Detecting at risk persons reflects the use of the system for public health action. In the 2006 draft protocol, further public health action for high risk contacts of a VZV case is defined, although not as an objective of the system. The other original objective identified in the 2006 protocol of the system was to monitor the impact of the national varicella immunisation. The stakeholder interview suggests for contemporary users, monitoring the impact of vaccination is no longer a priority objective of the system.

When asked if stakeholders thought the system performed well against objectives there was a neutral-to-agreed majority in terms of monitoring trends. In contrast though the majority of stakeholders disagreed that the system performed well at detecting high risk contacts or aided in evaluating vaccine effectiveness.
General practitioner survey

A total of 36 surveys were returned following invitation to participate to 413 general practitioners on the Capital Health Network (CHN) distribution list. This represents a response rate of 8.5%. The total number of responses to survey questions also varied as not all respondents answered all questions. Of respondents the mean number of hours practiced per week was 32.8 (range 5-70 hours); and, the number of years practiced ranged from 0–44 years.

The low response rate may represent the low engagement of general practitioners with VZV surveillance in the ACT. Over half (56%; 20/36) of respondents reported being unaware that either varicella or herpes zoster was notifiable in the ACT. Of respondents that were aware that varicella or herpes zoster was notifiable, only 31% (5/16) reported being aware that both clinical and laboratory confirmed diagnoses were notifiable.

The final question in the survey asked was whether VZV surveillance was useful to general practitioners. Seventy-one percent (24/34) respondents replied they did not think surveillance was useful; of these responses 20 provided written responses to a ‘why’ prompt. Almost half (45%) reported they were unaware that a surveillance system for VZV existed, 30% reported a lack of feedback or reporting to GPs; 15% thought that surveillance does not influence clinical practice and 5% reported they had no contact with the system. One respondent reported they were “unsure”.

Simplicity

The notification system for VZV is simple with regards to its structure and ease of operation. When VZV was added to the notifiable condition list in the ACT, additional fields for varicella, herpes zoster and VZV unspecified were added to existing system infrastructure. The manual entry system for notifications, and export functions of the NDMS directly to Microsoft Excel means the system is easily operable and requires limited technical training. The majority of internal stakeholder surveys reported the process of notifying a case was “easy”, including the pathology laboratory representative. In contrast only five out of 34 general practice survey responses reported notification being “easy” with 41% (14/34) of respondents reporting they were “unsure how to notify”. Prompted to identify barriers to notification the most frequent response (5/34) was “time”. Although structurally the
process of clinical notification may be simple, in practice it appears that either a lack of knowledge or the time taken to notify complicates the process.

National case definitions for varicella and herpes zoster should make it easy for CDCS staff to confirm a case. The internal survey however found users reported classification between varicella and herpes zoster cases was “not easily obtained”. This is likely because laboratory notifications do not necessarily detail which clinical manifestation of disease the test has been requested for. Complexity is added when a notification is not completed by both the pathology laboratory and the requesting doctor. Table 1 shows that although required by the CoP 2006 and 2017 notifications from medical practitioners is not common place in the ACT. Walk-In-Centres, who cannot request pathology, make up the largest proportion of probable cases notified and laboratories make up the largest proportion of confirmed cases.

Table 1: Count and percentage of VZV notifications by disease type, confirmation status and notifier, ACT, 2006–2016

<table>
<thead>
<tr>
<th>Disease type</th>
<th>Medical</th>
<th>Pathology laboratory†</th>
<th>Other/missing‡</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>varicella</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>confirmed</td>
<td>28 (82.4%)</td>
<td>34 (17.0%)</td>
<td>146 (73.4%)</td>
<td>199</td>
</tr>
<tr>
<td>probable</td>
<td>27 (20.9%)</td>
<td>129 (97%)</td>
<td>1 (0.8%)</td>
<td>133</td>
</tr>
<tr>
<td>herpes zoster</td>
<td>4 (25%)</td>
<td>16 (2.2%)</td>
<td>715 (96.9%)</td>
<td>738</td>
</tr>
<tr>
<td>confirmed</td>
<td>1 (50%)</td>
<td>2 (0.3%)</td>
<td>715 (99%)</td>
<td>722</td>
</tr>
<tr>
<td>probable</td>
<td>3 (21.4%)</td>
<td>14 (87.5%)</td>
<td>0 (0%)</td>
<td>16</td>
</tr>
<tr>
<td>unspecified</td>
<td>11 (45.8%)</td>
<td>24 (1.9%)</td>
<td>1245 (97.1%)</td>
<td>1276</td>
</tr>
<tr>
<td>confirmed</td>
<td>6 (75%)</td>
<td>8 (0.6%)</td>
<td>1239 (98.3%)</td>
<td>1260</td>
</tr>
<tr>
<td>probable</td>
<td>5 (31.3%)</td>
<td>16 (100%)</td>
<td>0 (0%)</td>
<td>16</td>
</tr>
</tbody>
</table>

*calculated as percentage of total medical notifications using ‘Medical Total’ Column as denominator
†calculated as percentage of total notifications using ‘Total’ Column as denominator
‡includes childcare centres, “others” and missing or unknown notifiers
Flexibility

Since becoming notifiable in 2006, the CDCS has undergone one database migration from an older database to the current NDMS (Rebecca Hundy 2017, personal communication, August). The flexibility of the surveillance system to migrate data between compatible databases is a strength. Providing there are no changes in reporting practices and core data remains the same, data is comparable over time. The internal stakeholder survey however elucidated that the current database was not considered to be flexible to changes, with users who responded reporting they either ‘disagreed’ or ‘strongly disagreed’ that it was easy to make additional changes (5/9); or that it was easy to access required IT support (3/6), respectively.

In response to surges in cases, such a large outbreak, 33% (3/9) of internal stakeholders that the system had the resources and flexibility to accommodate increased demand e.g. multiple users at once with limited delays. This feeling was somewhat contradicted by the pathology laboratory representative who also “agreed” the surveillance system could accommodate surges. When asked if the system could be managed (and still meet its objectives) at reduced staff capacity, 44% (4/9) internal stakeholders reported they disagreed the system could do so. These sentiments expressed by stakeholders suggests that although the system itself is flexible, that current infrastructure (database) adds rigidity to the system.

Data quality

Most internal respondents were either neutral (3/9) or disagreed or strongly disagreed (3/9) the ACT VZV surveillance system produced high quality data. Only one respondent reported being aware of any quality assurance process undertaken to ensure data quality, stating they were aware of “routine and annual data cleaning”. Follow-up discussion identified that indeed data cleaning took place as part of annual reporting requirements to the NNDSS. Internal stakeholders however reported mixed opinions regarding the ability of the system to provide data that meets NNDSS reporting requirements.

If a laboratory notification does not provide clinical evidence of classification between varicella or herpes zoster, the case will likely be reported as unspecified. The bulk of notifications received by the system are directly from pathology laboratories (Table 1), consequently, a large proportion of notifications are not useful in the interpretation of disease trends. The proportion of unspecified notifications however, has slightly decreased in the last two years (Table 2), indicating data quality may be improving.
Table 2: Count and proportion of notifications by year and disease, 2006–2016

<table>
<thead>
<tr>
<th>year</th>
<th>Varicella (%)</th>
<th>herpes zoster (%)</th>
<th>Unspecified (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>28 (26.2%)</td>
<td>8 (7.5%)</td>
<td>71 (66.4%)</td>
<td>107</td>
</tr>
<tr>
<td>2007</td>
<td>9 (7.7%)</td>
<td>6 (5.1%)</td>
<td>102 (87.2%)</td>
<td>117</td>
</tr>
<tr>
<td>2008</td>
<td>12 (9.7%)</td>
<td>7 (5.7%)</td>
<td>105 (84.7%)</td>
<td>124</td>
</tr>
<tr>
<td>2009</td>
<td>2 (2.5%)</td>
<td>12 (14.8%)</td>
<td>67 (82.7%)</td>
<td>81</td>
</tr>
<tr>
<td>2010</td>
<td>4 (3.3%)</td>
<td>31 (25.4%)</td>
<td>87 (71.3%)</td>
<td>122</td>
</tr>
<tr>
<td>2011</td>
<td>11 (7.9%)</td>
<td>28 (20.1%)</td>
<td>100 (71.9%)</td>
<td>139</td>
</tr>
<tr>
<td>2012</td>
<td>16 (8.2%)</td>
<td>52 (26.5%)</td>
<td>128 (65.3%)</td>
<td>196</td>
</tr>
<tr>
<td>2013</td>
<td>22 (10.4%)</td>
<td>52 (24.5%)</td>
<td>138 (65.1%)</td>
<td>212</td>
</tr>
<tr>
<td>2014</td>
<td>63 (19%)</td>
<td>92 (27.7%)</td>
<td>177 (53.3%)</td>
<td>332</td>
</tr>
<tr>
<td>2015</td>
<td>65 (16.8%)</td>
<td>196 (50.8%)</td>
<td>125 (32.4%)</td>
<td>386</td>
</tr>
<tr>
<td>2016</td>
<td>100 (18.9%)</td>
<td>254 (47.9%)</td>
<td>176 (33.2%)</td>
<td>530</td>
</tr>
<tr>
<td>Total</td>
<td>332</td>
<td>738</td>
<td>1276</td>
<td>2346</td>
</tr>
</tbody>
</table>

Date of onset was reported to be poorly recorded in discussions with CDCS staff. However, data extracted show 100% completion of onset date for all notifications. This is due to the practice of filling the onset date with the specimen collection date when a date of onset is not indicated in the notification.

Figure 12–13 show the proportion of cases where onset date is not identical to specimen collection date for each disease classification, indicating a suspected ‘true’ onset date was provided in the notification. For varicella, herpes zoster and unspecified notifications the discrimination between onset date and specimen collection date was high (almost 100%) for most years prior to 2014. From 2014 onward the discrimination has reduced dramatically potentially indicating reduced data quality.
Figure 11: Proportion of varicella notifications missing or having unknown indigenous status or immunisation status fields, and the proportion of varicella notifications with onset date and specimen collection date reported as different, ACT, 2006–2016

Table 3 shows that the proportion of unspecified cases was much higher in the prior to 2014. The reduction in onset and specimen date discrimination paired with increased notifications may indicate data quality being compromised as either more cases occur in the community or more cases are ascertained by the surveillance system (increased testing or increased clinical notification). The number of unspecified cases has reduced between the time periods discussed, which may be an offset against increased varicella and herpes zoster classification.

Table 3: Notifications 2006–2013 and 2013–2016 by disease classification

<table>
<thead>
<tr>
<th>year</th>
<th>varicella (%)</th>
<th>herpes zoster (%)</th>
<th>unspecified (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006–2013</td>
<td>104 (31%)</td>
<td>196 (27%)</td>
<td>798 (63%)</td>
</tr>
<tr>
<td>2014–2016</td>
<td>228 (69%)</td>
<td>542 (73%)</td>
<td>478 (37%)</td>
</tr>
</tbody>
</table>

Reporting of immunisation status has previously only been of concern for cases of varicella. For the majority of notifications vaccination was reported as either missing or unknown, with under half (42.5%) of varicella cases reported cases as vaccinated or not vaccinated (Table 4). Very few unspecified cases reported vaccination status and less than 2% of
herpes zoster cases had a reported vaccination status (Table 4). This is unsurprising considering Zostavax® has only recently become readily available and free under the NIP for certain age cohorts. Over time the proportion of cases where immunisation status is missing or unknown for varicella has not changed drastically, but has remained over a third of notifications (Figure 11).

Recording of indigenous status for confirmed notifications is summarised in Table 4. Indigenous status was missing for 27%, 37%, and 68% of varicella, herpes zoster and unspecified notifications respectively. The proportion of notifications missing indigenous status remained high in the period before 2013. For unspecified cases there was a large improvement in indigenous status classification in 2010.

**Table 4: Recorded immunisation status counts and percentages by disease classifications, ACT, 2006–2016**

<table>
<thead>
<tr>
<th>Immunisation status</th>
<th>varicella</th>
<th>herpes zoster</th>
<th>VZV unspecified</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully vaccinated for age for this disease</td>
<td>93 (28%)</td>
<td>7 (0.9%)</td>
<td>45 (3.5%)</td>
<td>145 (6.2%)</td>
</tr>
<tr>
<td>Natural immunity</td>
<td>2 (0.3%)</td>
<td>1 (0.1%)</td>
<td>3 (0.1%)</td>
<td></td>
</tr>
<tr>
<td>Not Applicable</td>
<td>4 (1.2%)</td>
<td>7 (0.9%)</td>
<td>5 (0.4%)</td>
<td>16 (0.7%)</td>
</tr>
<tr>
<td>Not vaccinated for this disease</td>
<td>48 (14.5%)</td>
<td>5 (0.7%)</td>
<td>42 (3.3%)</td>
<td>95 (4.5%)</td>
</tr>
<tr>
<td>Partially vaccinated for age for this disease</td>
<td></td>
<td></td>
<td>1 (0.1%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>113 (34%)</td>
<td>473 (64.1%)</td>
<td>332 (25.2%)</td>
<td>908 (38.7%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>74 (22.3%)</td>
<td>224 (33.1%)</td>
<td>860 (67.4%)</td>
<td>1178 (50.2%)</td>
</tr>
<tr>
<td>Total</td>
<td>332</td>
<td>738</td>
<td>1276</td>
<td>2346</td>
</tr>
</tbody>
</table>

Discussion with CDCS staff was unable to explain what might have caused this improvement, or why it was not sustained. From 2014 onwards for all disease classifications the proportion of case where indigenous status is missing has been greatly reduced. Discussion with CDCS staff elucidated changes in notification entry practices may be responsible, with data entry staff starting to access clinical records in order to identify notification status if not detailed on a laboratory report.
Figure 12: Proportion of herpes zoster notifications missing or having unknown indigenous status or immunisation status fields, and the proportion of herpes zoster notifications with onset date and specimen collection date reported as different, ACT, 2006–2016

Figure 13: Proportion of VZV unspecified notifications missing or having unknown indigenous status or immunisation status fields, and the proportion of VZV unspecified notifications with onset date and specimen collection date reported as different, ACT, 2006–2016
Acceptability

The GP survey, although a limited sample, highlighted that many GPs are likely not aware that varicella and herpes zoster is notifiable. When asked what they thought were barriers to notification the most common response was “unsure how to notify”. A summary table of GP responses is provided in Table 5. Low acceptability amongst GPs may therefore be driven by a lack of awareness and/or efforts to engage providers in the system. Although knowledge may be a driver of poor engagement, the poor response rate of GPs to the electronic survey may indicate an initial lack of willingness to be involved in the system or a lack of willingness to engage government health authorities.

A lack of awareness of the system and lack of feedback/reporting was most commonly identified as reasons limiting the use of the surveillance system. Feedback of surveillance data could serve as a prompt to motivate, encourage and maintain notification. There are currently no regular reporting structures to disseminate VZV surveillance data to stakeholders. Inclusion of data into formal reports such as the Chief Health Officer Annual Report is on an ad-hoc basis.

In contrast to the GP survey, the public pathology provider indicated that the system readily acceptable from the laboratory perspective. Notification of laboratory confirmed VZV infection was considered an effective method for disease surveillance, as was the automated fax process of notification between the lab and CDCS.

Sensitivity

The sensitivity of VZV surveillance in the ACT is likely to be low. Reduced sensitivity in terms of case ascertainment may be unproblematic in surveillance systems with the objective of monitoring disease trends over time, providing surveillance methodology over time does not change. The objectives of the ACT VZV surveillance system are just that, however, low sensitivity can also compromise the representativeness of the data. Moreover, as the incidence of disease (both varicella and herpes zoster) declines with greater vaccination coverage the ability to detect outbreaks of disease will become increasingly important. A high degree of sensitivity is therefore important to the surveillance system.
Table 5: Responses to General Practitioner stakeholder survey

| Question                                                                 | Response                                                                 | Number of Responses (%)                                                                 |
|==========================================================================|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Were you previously aware that clinically diagnosed and laboratory confirmed chickenpox and shingles are notifiable in the ACT? | Yes, aware clinical diagnoses are notifiable | 5 (14.29%)  5 (14.29%)  6 (17.14%)  19 (54.29%)                  | 35                                                                      |
| How often do you notify a patient with a clinical presentation of chickenpox? | Never            | 16 (47.06%)  5 (14.71%)  3 (8.82%)  4 (11.76%)                  | 34                                                                      |
| How often do you notify a patient with a clinical presentation of shingles? | Never            | 19 (57.58%)  4 (12.12%)  2 (6.06%)  2 (6.06%)                  | 33                                                                      |
| How often do you swab a lesion to obtain laboratory evidence to confirm a chickenpox clinical diagnosis?* | Never            | 5 (14.71%)  15 (44.12%)  6 (17.65%)  1 (2.94%)                  | 34                                                                      |
| How often do you swab a lesion to obtain laboratory evidence to confirm a shingles clinical diagnosis?* | Never            | 11 (32.35%)  12 (35.29%)  4 (11.76%)  0 (0%)                  | 34                                                                      |
| How easy/difficult do you currently find it to notify a case of chicken or shingles? | Unsure how to notify | 14 (41.18%)  3 (8.82%)  1 (2.94%)  10 (29.41%)                  | 33                                                                      |
| Do you feel the current chickenpox and shingles surveillance system in the ACT is useful to general practitioners? | Yes              | 10 (29.41%)  24 (70.59%)                                      | 34                                                                      |
The sensitivity of VZV surveillance is difficult to determine, but it is likely that notifications underestimate disease incidence. Figure 14 shows the factors that influence notification and highlights a large proportion of cases are likely to not be notified. PCR testing for varicella has been available since VZV become notifiable in the ACT, although there has been changes in equipment test sensitivity and specify has been comparable over time. Test characteristics are therefore unlikely to have impacted surveillance sensitivity over time.

*Source: Adapted from NNDSS Annual Report 2010

**Figure 14:** ACT VZV surveillance system notification pathways of varicella-zoster virus infections

In the ACT most notifications for VZV are made by pathology laboratories (Table 1). The sensitivity of the system is thus reliant firstly on cases seeking care; and secondly on clinicians to notify on clinical confirmation of illness, or collection a specimen for laboratory confirmation. This hinders the sensitivity of the system. In the first instance most varicella and herpes zoster cases generally develop mild disease which reduces the number of cases that seek medical attention. Secondly, the GP survey highlighted that respondents most frequently reported “rarely” or “never” obtaining a specimen for either a varicella or herpes zoster case. Although the proportion of varicella cases notified by medical officers and pathology laboratories is relatively similar, almost all unspecified notifications are made by pathology laboratories, many of which may be cases of varicella (Table 1). The GP
stakeholder survey elucidated that notification of clinical varicella or herpes zoster was most frequently reported to be ‘never’ undertaken by respondents; 46% (16/35) for varicella and 59% (20/34) for herpes zoster (Table 5) which indicates poor sensitivity in the system.

The lack of clinical information, or specification, on positive laboratory results means a large proportion of notifications are classified as ‘unspecified’, reducing the sensitivity of the system for the surveillance of both varicella and herpes zoster.

In the ACT notifications for both varicella and herpes zoster are however increasing over time (Figure 7 & Figure 8). To contextualise these trends, Figure 15 and Figure 17 compares age group specific notification rates from the ACT to SA. In SA, VZV has been notifiable since 2002, and the low proportion of unspecified cases reported by the state makes SA data the gold standard of VZV notification data in the country. In SA, varicella notification rates have dropped in all age groups over time (Figure 15). In contrast notification rates in the ACT increased over time, in particular from 2013 onwards, indicating that sensitivity may be increasing over time or a different epidemiological trend although this is less likely. This could be confirmed by reviewing the number of tests.
performed and calculating the proportion of positive tests. If the test rate has increased over time and the proportion of positive tests over time has remained stable it would suggest the system is ascertaining more cases in the community, thus has increased in sensitivity.

![Graph showing proportion of varicella notifications by notifier and notification rate per 100,000 population, for children aged 0–4 years, ACT, 2006–2016.](image)

In the 0–4 year age group, the notification rate was high in 2006. In 2006, 40% (11/27) of notifications for varicella were made by clinicians and only 11% were made by pathology laboratories – the majority of notifications did not have a notifying source reported. During other years with increased notification rates, 2013–2016, the proportion of tests by clinicians was also high (Figure 16). Case ascertainment appears to increase with notifications from clinicians indicating large underestimation of illness in young children where the bulk of the disease burden lies, and where vaccine impacts are most identifiable. The quadrivalent combination vaccine contain measles, mumps, rubella and varicella (MMRV) replaced the monovalent vaccine on the NIP for children aged 18 months in mid-2013. Subsequently coverage assessed in 2014 at 24 months increased nationally. It is plausible the introduction of the MMRV vaccine drove improved notification practices in clinicians through increased awareness. This phenomenon would also explain notification trends in 2006 following the introduction of the initial varicella vaccine to the NIP. If this
was the case, then keeping clinicians engaged in surveillance is an important consideration in improving the sensitivity of the current system.

In both South Australia and the ACT notification rates for herpes zoster have increased over time in most age groups (Figure 17). It is difficult to determine if the similar trends indicate that disease specific (herpes zoster) surveillance sensitivity is improving, or if disease

Figure 17: Herpes zoster age specific notification rates per 100,000 population, SA and ACT, 2006–2016
incidence is increasing or if factors such as community awareness and health seeking behaviours are influencing presentation. Again, an analysis of testing trends and the proportion of positive tests would provide context as very few notifications made for herpes zoster in the ACT are made by clinicians. The sensitivity of the system may be improving by a factor of increased testing, and/or improved case classification, which is evident in the reduced proportion of unspecified cases over time (Table 2 & Table 3). Alternatively, disease incidence may be increasing and sensitivity remains poor.

The system will also likely prove useful in the future to detect outbreaks of varicella as incidence becomes less frequent. Despite the limitations in the system discussed. The sensitivity of the system to detect clusters in its current operation should naturally improve as incidence declines.

**Predictive value positive**

The most commonly used diagnostic method to test for VZV in the surveillance system was nucleic acid testing by PCR, which accounted for 98.1% of all laboratory confirmed notifications during 2006–2016. PCR is the most sensitive diagnostic test for VZV by methods used by the ACT public pathology provider, test sensitivity ~99% and specificity ~100% (Jennifer Ridgeway 2017, personal communication, November), and has been demonstrated high diagnostic accuracy for VZV testing.12

There were 713 confirmed herpes zoster notifications, 98.7% (713/7722) confirmed by PCR. Similarly, 97% (1238/1276) of confirmed VZV unspecified notifications were PCR positive. PCR positive notifications account for almost all notifications for these classifications. Considering the confirmed case definitions for herpes zoster and VZV unspecified require laboratory confirmation and the high sensitivity and specificity of PCR testing. It is reasonable to assume the PVP for herpes zoster and VZV unspecified is likely high. Clinical diagnosis of herpes zoster is rare in the ACT, with only 16 probable case across an eleven year period. These cases were not reviewed to assess clinical likelihood of disease; however, the characteristic nature of vesicular rash suggests PVP for clinically diagnosed probable cases is likely also high.

There were 148 confirmed varicella notifications and 74.7%(148/198) were PCR tested positive. Clinically confirmed notifications accounted for 22.2% (44/198) of notifications. The proportion on probable varicella cases, 40% (133/332) is much higher for varicella than
herpes zoster. However, as with herpes zoster the PVP of clinically diagnosed is unknown. Similar to herpes zoster the characteristic clinical presentation of varicella is also likely suggestive of high PVP for clinical diagnosis.

A high degree of confidence in the PVP of clinical diagnosis however may not be sustainable. The introduction of varicella vaccine to the NIP and the National Herpes Zoster Vaccination Program should see decreased rates of disease. Decreased rates have the potential in the future to be accompanied by decreased PVP of clinical diagnosis as fewer new doctors have experience with VZV. In addition, disease in vaccinated individuals has been observed in previously vaccinated populations to be relatively common. This disease often presents with more mild illness with fewer lesions which may not progress to vesicles. Swabbing of lesions to obtain laboratory evidence to confirm clinical diagnosis was also reported most commonly to be either ‘never’ undertaken or ‘rarely’ undertaken; 17% (6/35) and 43% (15/35) respectively for varicella and 35% (12/34) each for herpes zoster and unspecified VZV. It will be important moving forward that as laboratory testing become increasingly important for surveillance, clinicians are responding accordingly.

**Representativeness**

The representativeness of a system refers to the ability of the data to accurately describe the occurrence of disease over time and its distribution in the population by persons and place. Notification surveillance systems inherently likely under-represent incidence. Considering the notification pathway shown in Figure 14, a number of assumptions regarding health seeking behaviours, access to care, and clinician diagnostic methods need to be met to make the system fully representative of the population it attempts to capture. Comparison of surveillance data to hospitalisation data or to GP presentation data would be a valuable means of assessing the representativeness of the surveillance system. Unfortunately, at the time of the evaluation hospitalisation data was not available. The GP sentinel surveillance network (ASPREN) has very few ACT based practitioners, and was not considered as useful in the evaluation.

Internal stakeholder survey responses indicated that the system was perceived as representative with over half of respondents (55%; 5/9) reporting that access to health services was available to the community as a whole. However, 87.5% (7/9) of respondents identified populations they perceived as being underrepresented by the system. Populations
identified included: lower socio-economic status, Aboriginal and Torres Strait Islander communities, culturally and linguistically diverse populations, and also children, and males.

**Timeliness**

The timeliness of the system reflects the efficiency between the different steps in the surveillance system.\(^{41}\) Although the objectives of the surveillance system do not necessitate timely notification; outbreak detection and public health follow up of high risk contacts benefits from timely notification. As varicella becomes viewed more as a preventable condition there will likely be increased demand for timeliness within the system

![Figure 18: Days between VZV onset and notification to CDC, ACT Health, ACT, 2006–2016](image)

The number of days between notification and onset, where onset is reported (44%; 1032/2346) are presented in Figure 18. The majority of notifications for all disease classifications were notified within 10 days after onset of symptoms; 90%, 89% and 83% for varicella, herpes zoster and VZV unspecified notifications respectively. For varicella and herpes zoster there were only six and ten cases respectively that were notified greater than three weeks after onset (Figure 18). For unspecified cases however there were 64 cases with greater than 35 days between onset and notification, ranging from 36–735 days,
median 286 days. It is probable this reflects poor data quality (data entry errors) rather than true delays notifications.

CDCS stakeholders were confident that notification from laboratories is received in a timely manner (100%, 7/7). Just over half, 57%, (4/7) agreed notification by clinicians (when made) is timely, and the same amount agreed that public health follow up is conducted in a timely manner.

**Stability**

Surveillance of VZV is part of the ACT’s notifiable disease surveillance program and as such benefits from being part of well-established surveillance infrastructure. The NDMS is secure and backed-up creating a stable environment for data storage which allows data to be released through export functions. Staffing requirements for the data entry and management of the system are not likely to be exceeded. The NDMS does suffer from occasional unscheduled outages and becomes inaccessible to staff. Of CDCS staff, 71% (5/7) reported they believe the operation of system could be destabilised and the same amount reported a recalling a time in the previous three years when this had occurred. The use of a fax based system was reported to malfunction, interrupting the stream of notifications being received.

**Conclusions**

VZV was added to the notifiable condition list in the ACT in 2006 following the introduction of varicella vaccine to the NIP in late 2005 with the objective to monitor the impact of vaccination. In the 11 years since the inception of VZV surveillance in the ACT, it appears the extent this objective is being met is questionable. The usefulness of the surveillance system to measure the impact of vaccine on disease incidence for varicella is generally weak. The timing of the inception of surveillance means notification rates pre- and post-vaccine cannot be calculated for varicella. Moreover, stakeholder surveys demonstrate the priority of system objectives has changed overtime.

Detection and monitoring of disease trends and public health follow up of high risk contacts were given top priority of objectives ranked by internal stakeholders. In meeting these objectives the system does produce data that shows trends over time and by demographic factors, such as age, and is comparable to national VZV disease surveillance data. Furthermore, the proportion of unspecified notifications appears to be decreasing making data more meaningful and enhancing the ability to follow up cases by classifying disease. In
its current state however, there are important limitations in the simplicity, data quality, acceptability, sensitivity and representativeness of the system.

Although there is legislative requirement in the ACT for both clinical and laboratory confirmed notification of varicella or herpes zoster, limited engagement with, and buy-in from health care providers – evident in the general practice survey findings – means the system is mostly reliant on automated laboratory notification. Subsequently a proportion of notifications are continually classified as unspecified cases which are of limited use epidemiologically. The large number of unspecified notifications that are unable to be further classified also complicates the system. Though there was consensus amongst internal stakeholders regarding the simplicity of the system in theory, without clinical reporting or notes the task of classifying disease requires increased resources by surveillance officers and public health nurses. The low level of engagement with clinicians may represent poor acceptability of the system, however the findings from the GP survey suggest it is equally likely that lack of awareness may be the cause. The completeness of data fields was seen to improve in the period directly after vaccine introduction or changes to the NIP schedule, likely resulting from improved clinician engagement in surveillance i.e. notifying. Sustaining such trends may not be difficult to achieve. A lack of feedback or reporting was reported to be a limitation of the systems usefulness by GPs that could be easily overcome.

The inherent limitations of passive surveillance regarding sensitivity may not be so easily addressed. Collecting more complete notification data will improve ascertainment, however the system is still reliant on cases completing the notification pathway. As rates decrease and breakthrough disease increases, increasing laboratory testing to confirm cases will be important to maintain assumed PVP standards and will additionally improve case ascertainment. However, as varicella becomes increasingly less frequent in the community it is likely that the sensitivity of the system will increase in its ability to detect clusters or outbreaks of disease. The rigidity of the database to make changes identified by stakeholders will need to be addressed as enhanced data will be required for investigations.

There is potential for the system to be useful to monitor the impact to the National Herpes Zoster Vaccination Program. The proportion of notifications reported as unspecified over time has decreased, especially in recent years improving the quality of notification data in
for a pre-vaccine era. Looking towards the future, it is important the system is able to capture the data required to measure this impact.

**Recommendations**

As an outcome of this evaluation the CDCS may want to consider the following recommendations to enhance the capacity of the VZZ surveillance system to meet its objectives identified through the evaluation.

**Usefulness**

The utility of the system can only be measure against defined objectives. This evaluated identified a lack of such objectives and explored what users of the system perceive as it objectives.

**Recommendation 1**

- Define the objectives of the surveillance system that align with the reporting requirements by the NNDSS and the appropriate ACT Health strategic plans.

  Note: This evaluation may provide a useful resource in defining objectives

**Recommendation 2**

- Review Standard Operating Procedure (SOP) for public health follow up and management of VZV infection to ensure surveillance is in line with the objectives identified by internal stakeholder. This is especially important in response to the anticipated decline of varicella incidence, and potential to identify breakthrough disease clusters.

**Recommendation 3**

- Rapidly develop a strategy to assess the impact of the herpes zoster vaccine in the ACT.

  Note: In developing this strategy additional changes to the surveillance system not identified here may come to light.
Chapter 5

Simplicity

Recommendation 4

- Implement a notification tool that simplifies the notification process for clinicians –
  E.g. Faxing a simple enhanced data collection form to clinicians following receipt
  of a laboratory notification.

  Note: This recommendation also aims to improve: data quality, acceptability,
  sensitivity and representativeness

Flexibility & Stability

Recommendation 5

- Update the database to a more flexible, user-friendly interface that requires
  minimum external technical support or adequate access to technical support. The
  database should capture all required information, allow fields to be added or closed,
  allow for dual notification (clinical and laboratory in the report), and be able to link
  cases which will be important as the ability of the system to detect outbreaks
  increases.

  - Note: This recommendation also aims to improve: data quality, sensitivity and
    representativeness

Recommendation 6

- Migrate automated laboratory notification from a paper-based fax system to online
  using email. This process should remain automated and have a quality assurance
  function built in with backup storage on both sides. The CDCS should have a secure
  storage site for notifications on the network server.

Recommendation 7

- Develop a formalised System Change Log. Having data comparable over time is an
  important component of the system, this log should date and time all major
  surveillance decisions that will likely affect: how the system captures data e.g
  updated notification forms, changes to notification processes that might affect
Evaluation

timeliness, changes to case definitions, changes to reporting structures, addition or closure of fields.

Data quality

Recommendation 8

- Institute quality assurance (QA) practices into routine surveillance. Consider weekly extracting data and analysing to identify notifications where key field are not completed.

Acceptability

Recommendation 9

- Develop regular reporting structures to feedback to health practitioners. Consider a surveillance report for all notifiable conditions of interest that includes proportion of clinical and laboratory notifications.
References


Appendix 1

Internal stakeholder survey

The Health Protection Service (HPS) is conducting an evaluation of varicella-zoster virus (VZV) infection surveillance. I am writing to seek your assistance in conducting this evaluation by completing a survey.

Surveillance for VZV infection in the ACT is conducted through the ACT Notifiable Diseases Surveillance program. As a part of this program, VZV infection (including both chickenpox and shingles) is notifiable by General Practitioners (GPs) to the HPS under the Public Health ACT 1997.

Surveillance of VZV through notifications is important to understand the epidemiology of the disease, determine risk factors, implement disease control measures, and assess the effectiveness of the chickenpox and shingles immunisation programs. It is therefore important that the current surveillance system is evaluated to ensure the system captures quality data, in a timely, effective and efficient manner.

The evaluation will include a range of stakeholder interviews to seek their views on the surveillance system. As a valued stakeholder in the surveillance of VZV and other notifiable conditions, I would like to invite you to participate in this evaluation by completing the attached survey. Instructions on how to complete and return can be found on the back of the survey.

It is expected that the evaluation will provide recommendations to improve surveillance of VZV infection in the ACT to enable the system to better achieve current objectives, and accommodate additional objectives in the future. We will provide you with a summary of the outcomes of the evaluation once it is completed.

We thank you for your assistance in this evaluation and for your contribution to the ongoing improvement of disease surveillance.

1. Please provide your name below.

2. Please select your field you work from the list below

- Disease surveillance and investigation (public health)
- Clinical
- Pathology
- Immunisation and/or policy
### Surveillance system utility

The questions on this page refer to the ability of the system to meet its objectives

3. Please rank the following objectives of VZV surveillance in order of importance with 1 being most important and 8 being least important.

- [ ] Detect outbreaks
- [ ] Detect and monitor disease trends
- [ ] Detect persons (contacts) at high risk and inform appropriate public health follow-up
- [ ] Characterize cases and define risk factors
- [ ] Collect and report data to local and national databases
- [ ] Evaluate vaccine effectiveness
- [ ] Inform immunisation policy
- [ ] Provide data for public health program development, monitoring and evaluation

4. The current VZV surveillance system performs well against the following objectives:

<table>
<thead>
<tr>
<th>Objective</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>No opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detect outbreaks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detect and monitor disease trends</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Detect persons (contacts) at high risk and inform appropriate public health follow-up</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characterize cases and define risk factors</td>
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<td></td>
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<tr>
<td>Collect and report data to local and national databases</td>
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<tr>
<td>Evaluate vaccine effectiveness</td>
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<tr>
<td>Inform immunisation policy</td>
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<tr>
<td>Provide data for public health program development, monitoring and evaluation</td>
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</tr>
</tbody>
</table>
5. What do you use the information from the VZV surveillance system for? Please tick all applicable boxes
- Identify high risk contacts for public health follow-up
- Research and reporting
- Detect outbreaks
- Monitor disease trends
- Develop immunisation policy
- Clinical decision making
- Funding & operational planning
- Public health program development, monitoring and evaluation
- Other (please specify)

6. Overall, the VZV surveillance system serves its purpose.
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion

7. The VZV surveillance system allows me to fulfil my outline VZV surveillance and public health follow-up duties?
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion

8. To your knowledge, has VZV surveillance system led to the generation of reports, or publication of data in appropriate reports?
- Yes
- No
- If yes, please provide details
Surveillance system attributes

The questions on this page refer to the attribute: simplicity

9. It is easy to notify a case of VZV.
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
   - No opinion
   - Not applicable

10. Specification between chickenpox and shingles from clinicians is easily obtained.
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree
    - No opinion
    - Not applicable

11. It is easy to complete all data fields for a case of VZV.
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree
    - No opinion
    - Not applicable
The questions on this page refer to the attribute: acceptability

12. VZV notification is important.
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
   - No opinion
   - Not applicable

13. Within my role, I believe time spent on VZV surveillance is worth my time.
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
   - No opinion
   - Not applicable

14. Notification of clinically diagnosed VZV cases is an effective method for disease surveillance.
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
   - No opinion
   - Not applicable

15. Notification of laboratory confirmed VZV cases is an effective method of disease surveillance.
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
   - No opinion
   - Not applicable
16. The current requirements (telephone, fax or postal notification of laboratory confirmed or clinically suspected cases) for VZV case reporting are reasonable, taking into account the time taken to notify, ease of notification, need for IT support etc.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

The questions on this page refer to the attribute: flexibility

17. The VZV surveillance system is able to adapt to changes in case definitions.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

18. IT support for the VZV surveillance system database is easily accessible.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

19. If required, it is easy to make changes to the system to collect additional information.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable
20. The surveillance system is able to accommodate multiple users in 'surge' scenarios, such as large outbreaks.
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

21. The surveillance system can be managed effectively (still meets objectives) at reduced staff capacity.
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

The questions on this page refer to the attribute: data quality

22. Data from the VZV surveillance system is of high quality (is accurate and contains no errors)
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

23. Are you aware of quality assurance processes within the system to ensure high quality data?
- Yes
- No
- If yes, please list the processes you are aware of.
24. The structure and processes of the surveillance system limits the potential for data entry errors.
○ Strongly agree
○ Agree
○ Neutral
○ Disagree
○ Strongly disagree
○ No opinion
○ Not applicable

25. Data is able to be extracted from the surveillance system that meets the NNDSS reporting requirements.
○ Strongly agree
○ Agree
○ Neutral
○ Disagree
○ Strongly disagree
○ No opinion
○ Not applicable
○ If you disagree, or strongly disagree what fields do you believe are missing?

The questions on this page refer to the attribute: sensitivity & positive predictive value (PVP)

26. The surveillance system identifies the majority of cases of VZV in the community
○ Strongly agree
○ Agree
○ Neutral
○ Disagree
○ Strongly disagree
○ No opinion
○ Not applicable

27. Clinicians do not wrongly diagnose patients with VZV and notify such cases.
○ Strongly agree
○ Agree
○ Neutral
○ Disagree
○ Strongly disagree
○ No opinion
○ Not applicable
28. The majority of VZV cases in the community have a laboratory test to confirm their diagnosis.
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

29. The surveillance system is able to detect an outbreak of VZV in the community.
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

The questions on this page refer to the attribute: representativeness

30. Access to health services for clinical diagnosis and/or laboratory testing are readily available to the community as a whole.
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- No opinion
- Not applicable

31. Do you think there are populations underrepresented by the surveillance system?
- Yes
- No
- If yes, please list the populations
32. The surveillance system captures data from health services that are accessible to the entire population.
   ○ Strongly agree
   ○ Agree
   ○ Neutral
   ○ Disagree
   ○ Strongly disagree
   ○ No opinion
   ○ Not applicable
   ○ If you do not agree, what population groups do you believe do not have access to services

The questions on this page refer to the attribute: timeliness

33. The surveillance system ensures public health follow-up of VZV are conducted in a timely manner.
   ○ Yes
   ○ No

34. Notification of laboratory confirmed VZV cases are notified in a timely manner.
   ○ Yes
   ○ No

35. Notification of clinically diagnosed VZV cases are notified in a timely manner.
   ○ Yes
   ○ No

36. Data from the surveillance system is made publicly available in a timely manner.
   ○ Yes
   ○ No

37. The structure and processes (receiving notifications, input of data, extraction of data and analysis of data) of the surveillance system allows timely response to potential outbreaks.
   ○ Yes
   ○ No

stability

38. Has there been any incidents in the last 3 years when the surveillance system database has not been available and required repair?
   ○ Yes
   ○ No
   ○ If yes, please (briefly) specify
39. Are there currently any risks that could destabilise the operation of the VZV surveillance system?

- Yes
- No
- If yes, please (briefly) specify

40. Has there been any incidents in the last 3 years where a technical disruption in the notification process affected system functionality?

- Yes
- No
- If yes, please (briefly) specify

Thank you for completing our survey, we greatly appreciate your time.

As part of the evaluation we would like to follow-up this survey with an informal interview either in person or by telephone discuss your responses in greater depth and to respond to any questions you might have or any further comments you have that were not addressed in the survey.

41. Are you willing to conduct the follow-up interview?

- Yes
- No

42. If, yes what is the most appropriate method to contact you to arrange the interview?

- Email
- Telephone
- Discuss at HPS in person
Appendix 2

General practitioner stakeholder survey

**Chickenpox/shingles disease surveillance evaluation - GP survey**

Thank you for taking the time to complete our survey. Please return the completed form via:
- fax to CDC at (02) 6205 1739;
- scan & email to sam.mcewen@act.gov.au; OR
- post to Health Protection Service Locked Bag 5005, Weston Creek, ACT 2611

Alternatively you can complete the survey online at [https://www.surveymonkey.com/r/vzvsurvey](https://www.surveymonkey.com/r/vzvsurvey)

Were you previously aware that clinically diagnosed and laboratory confirmed chickenpox and shingles are notifiable in the ACT?
- [ ] Yes, aware clinical diagnoses are notifiable
- [ ] Yes, aware laboratory confirmed diagnoses are notifiable
- [ ] Yes, aware both clinical and laboratory confirmed diagnoses are notifiable
- [ ] Not aware that chickenpox or shingles were notifiable

How often do you notify a patient with a clinical presentation of chickenpox/shingles?

**Chickenpox**
- [ ] Never
- [ ] Rarely
- [ ] Sometimes
- [ ] Often
- [ ] Always

**Shingles**
- [ ] Never
- [ ] Rarely
- [ ] Sometimes
- [ ] Often
- [ ] Always

How often do you swab a lesion to obtain laboratory evidence to confirm a chickenpox/shingles clinical diagnosis?

**Chickenpox**
- [ ] Never
- [ ] Rarely
- [ ] Sometimes
- [ ] Often
- [ ] Always

**Shingles**
- [ ] Never
- [ ] Rarely
- [ ] Sometimes
- [ ] Often
- [ ] Always

*If you do swab patients, ACT Health CDC recommends specifying suspicion of chickenpox or shingles on the pathology request form to enhance our surveillance data quality.

How easy/difficult do you currently find it to notify a case of chickenpox or shingles?
- [ ] Unsure how to notify
- [ ] Difficult
- [ ] Somewhat difficult
- [ ] Neutral
- [ ] Easy
- [ ] Very easy

What do you regard as barriers to notification?

Do you feel the current chickenpox and shingles surveillance system in the ACT is useful to general practitioners?
- [ ] Yes
- [ ] No – why not:

What year did you begin practicing in the ACT?___________

On average, how many hours a week do you practice?___________

If you have any questions please contact Sam McEwen at CDC on (02) 6205 9857 or at sam.mcewen@act.gov.au
Appendices
Appendix A

Teaching
Lesson from the Field

Lessons from the Field: Sam McEwen

The basics of preparing a time series analysis: Extracting and using climate data for basic time series analysis

Background

This lesson from the field (LFF) aims to inform other MAE scholars how to link climate data and health outcome data to generate time series plots. The purpose of the exercise is to stimulate peers to consider applying principles in environmental epidemiology by demonstrating the first steps of a time series analysis. The exercise will describe where and what types of climate data is readily available online and how to prepare these data for analysis.

Learning objectives

Upon completion of the exercise, you should be able to:

- Use the Bureau of Meteorology (BoM) Climate Data Online (CDO) service to download data.
- Clean climate data and link to health outcome data.
- Generate time series plots.
- Consider the methodology behind a time series analysis in detail.

Please complete tasks and questions related to the dataset and submit your responses in report template to sam.mcewen@act.gov.au by /05/2017
Exercise

You are the epidemiologist at the South Western Sydney Local Health District (SWSLHD) – one of the largest health districts in the state. You have recently been asked to work on a collaborative project with Liverpool Hospital. Liverpool hospital is the largest referral hospital in the district. The last analysis of the hospital’s catchment in 2011-2012 reported 92% of hospitalisations were residents of the South Western Sydney district, suggesting the hospital provides a good representation of the district.

“Over 47,000 patients (47146) were admitted to Liverpool Hospital in 2011-2012, with almost half (45%) coming from Liverpool (LGA) and 92% coming from the SWSLHD. Fairfield LGA supplied 25% of Liverpool Hospital’s inpatients, followed by Campbelltown (12%), Bankstown (4%), Campbell (3%), Wollondilly (2%), Wingecarribee (1%).

- Liverpool Hospital Operational Plan 2014-2018

The hospital’s operational plan 2014 -2018 is up for review. The current operational plan identifies in its Corporate Action B: Efficiency and Sustainability, that the threats posed by climate change on the environment and on individuals are increasingly recognised. The impact of health related events is likely to increase in public health importance, as climate change continues. Historically, heatwaves have been identified as being responsible for more deaths in Australia than any other natural hazard, including bushfires, storms, tropical cyclones and floods (Coates, Hayes et al. 2004). The forecasted increased frequency and severity of heatwaves and a rise in average temperatures therefore represents a significant public health concern.

The hospital has reached out to the SWSLHD to ask for epidemiological expertise in formally investigating the association between temperature and hospitalisations in the district to inform future policy.

As the resident Epi, have been tasked with undertaking the project. You decide you will undertake a time series analysis.

This lesson from the field will cover the initial steps of the project:

- Where to find and how to prepare freely available climate data from the Bureau of Meteorology
- How to generate time series plots with this data for initial descriptive analysis.
- How to undertake a time series regression is beyond the scope of the LFF, however, you will be requested to consider how to undertake further analysis which we will discuss in the TC.
You have been given:

- A map of the South Western Sydney Local Health District.
- A zip file containing downloaded climate data.
- A dta file for mock hospitalisations statistics for Liverpool Hospital.

Part one –

Finding your climate data

The BoM provides access to a range of climate statistics, recent weather observations and climate data through their CDO service. CDO provides data from the Australian Data Archive of Meteorology (ADAM), a database which holds weather observations dating back to the mid 1800s for some sites. A progressively increasing range of data is being made available from CDO in a variety of formats including data files (csv), PDF, graphs and maps.

We will be using the CDO service to download csv files.
Chapter 5

1. Go to the Climate Data Online website

The home page should look like this.

![Climate Data Online Home Page](image)

Exercise 1a

*Defining the climate measurement (variable) you are interested in investigating.*

What would you consider an appropriate climate measurement to investigate the effect of heat on hospitalisations? Why?
Exercise 1b

Defining from which stations you will extract your climate data.

Considering the catchment area of the hospital what exclusion/inclusion criteria would you consider for choosing which weather stations to extract data from?

2. The CDO service gives you two searching options. To start we will consider the Select using Text option to identify which climate variables are freely available and from which stations we are able to extract these data from.

2.1 Click the drop down option to review the available data. Select temperature.

2.2 Depending on which variable you are interested in. A range of observational and statistical measurements are available. For the purpose of this exercise select daily observations for maximum temperature.
3. **Using the Select using Text search option to find weather stations**

3.1 The search bar allows for open ended searches by entering the name city, council or region you are interested in. **Enter Liverpool into the search bar. Click find.**

3.2 The search will provide you ‘towns’ that meet your search criteria. In the Matching Towns section **select the first Liverpool.**

3.3 By Selecting Liverpool the website will identify the nearest stations to the town you selected in the ‘matching towns’ field. Note the station number is provided at the beginning of the line.

3.4 By selecting a station a figure will be generated showing the time period for which data is available from this station and how complete (%) that data is.

---

**Exercise 1c**

1. **Reviewing the nearest bureau stations which ones would you consider extracting data from and why?**
fining your exclusion/inclusion criteria for stations you are ready to extract your data. **Selecting your station of interest (e.g. Bankstown Airport) click Get Data.**

This will open up a new tab in your browser. Assuming you have made no changes to the year it will default to 2017. The new tab should look similar to the one below.

4.1 The initial data displayed will default to a spreadsheet for daily maximum temperatures for the current year.

4.3 Click on the *All years data* tab. By clicking on the tab a zip file will download. This attached file will contain a csv file with data for all years the station has available.

If you are interested in how to search and download CDO data using the **Select using Map** search option please see the appendix at the back of the exercise.
For the purpose of this exercise, CDO data has been downloaded for five weather stations in the South Western Sydney District. These files will be found in the attachment “South Western Sydney District weather stations”. The csv files have been converted into xls files to allow them to be imported into Stata.

Please open this file to continue with Part 2 of the exercise.

Part 2 –
Combining climate data

In this section of the exercise you will need access to STATA.

1. Open the folder attached named “South Western Sydney District weather stations” and open the xls file for Bankstown

**NOTE:** We will be using multiple files from this folder and importing to stata.

---

**Exercise 2a**

1. After reviewing the data is there any issues you can identify in the data?

2. What variables are you interested in for your times series plot?
2. There are four other weather station files for the South Western Sydney District. Please open these files and confirm the variables are consistent across all files.

3. Open Stata.

NOTE: We will be using multiple files from this folder and importing to stata.
Open up a new ‘do file’ and save. Set up your do file with the standard formats – change directory, set more off etc.

4. Import all xls files into stata and save as dta files using the same name as provided for the excel file.

5. We wish to combine the five weather station datasets to create one.

Exercise 2b

1. In this scenario what is the most appropriate command to combine these data sets and why?

2. Write down the state code to combine these datasets

*if you are unsure of the most appropriate command or are unsure of code please turn the page.
**Append:** adds observations to the existing variables. Append is appropriate, for instance, when you have data on hospital patients and then receive data on more patients.

![Addition Diagram]

The Append command allows you to combine multiple data sets at once e.g.

```
append using "dataset1" "datset3" "datset3"
```

6. After combing all five CDO exports into one dataset, save the dataset as ‘SWS_climatedata’.

7. We are interested in analysing the data between 2012-2016. Clean the data to remove all years before 2012 or data for the years 2017.

**Exercise 2c**

1. How many observations are in the data?

2. Each row in the dataset represents a day. Do the number of observations in the merged dataset suggest any missing data?

3. What is the highest and lowest Maximum temperature recorded for each year?

4. What is the mean maximum temperature for each year?

8. The dataset, as imported from the CDO exports, provides time variables in the form of Day, Month, Year. From these variables generate a new date variable.

   ```
   Gen edate = mdy(Month, Day, Year)
   Format edate %td
   ```

9. The reason we have extracted and combined data from 5 difference weather stations across the South Western Sydney region is to average out the weather
variable (Max Temperature) across the region to attempt to account for variations between stations.

We want to collapse the dataset to provide the average daily maximum temperature between the five weather stations.

Use the command below to collapse the dataset

```
Collapse (mean) MaximumtemperatureDegreeC, by (Year edate)
```

10. Browse the data. It should look like this.

![Data Browser Image](image)

11. You decide you want to look at the average temperatures observed in South Western Sydney over time. Create a scatter plot of mean average.

```
twoway (scatter MaximumtemperatureDegreeC edate)
```
12. Save the current data set ‘SWS_climatedata’.

**Part 3 –**

**Combining outcome data and generating time series plots**

In this section you will need to use the ‘mock hospitalisation statistics’ dta file attached to the LFF.

1. We wish to combine our ‘outcome’ (hospitalisations) dataset with our ‘exposure’ (weather-temperature) dataset.

**Exercise 3a**

1. In this scenario what is the most appropriate command to combine these data sets and why?

*If you are unsure about what command to use please turn the page*
**Merge** adds variables to the existing observations. Merge is appropriate, for instance, when you have data on survey respondents and then receive data on part 2 of the questionnaire.

![Diagram](A + B = A B)

The Merge command allows you to combine data sets horizontally.

2. Open the 'mock hospitalisation statistics' dta file and browse.

**Exercise 3b**

1. After reviewing the ‘mock hospitalisation statistics’ dataset, which variable will allow you to effectively merge the two datasets? (bonus question: what merge will work)

2. Merge your saved ‘SWS_climatedata’ dataset with the ‘mock hospitalisation statistics’ dataset. Use the stata command below filling in the question marks.

```
merge ?? edate using "SWS_climatedata"
```

*If you are using stata version 13 or earlier you may not be able to merge without converting the file. If this is the case, skip the merge and open the appropriate merged file for your version of stata in the old_stata_versions zip file attachment.

Browse your merged dataset. The data should look similar to below.
3. You decide to look at the distribution of deaths by the average maximum daily temperature in the South Western Sydney District. Create a scatter plot. Your graph should look similar to the graph below.

![Graph of hospitalisation vs. (mean) Maximum temperature Degree C]

**Exercise 3c**

1. Interpret your scatter plot.

2. Could you add a trend line to the graph? What would the stata code be?

3. (Bonus question) what test would be appropriate to test the correlation between average maximum temperature and death? What is the stata code?
4. As one of the last steps of your descriptive analysis you wish to generate a scatter plot of both the exposure (average max temperature) and the outcome (hospitalisations) over the entire study period. A plot like this can reveal high level patterns in the data.

You decide to run two simple scatter plots that look like below.
Exercise 3c

1. Write the stata code you used to generate these two plots.

5. The final graph you wish to make it to put both these graphs together on the same plot. To do so you can use the time series line plot function for two way graphs.

\begin{verbatim}
twoway (scatter hospitalisation edate, msize(tiny) yaxis(1) yscale(range(0))) (scatter MaximumtemperatureDegreeC edate, msize(tiny) yaxis(2) )
\end{verbatim}
Exercise 3d (OPTIONAL)

Read the attached article on time series regression studies in environmental epidemiology. In this LFF we have taken the first steps in conducting a time series analysis.

Looking at our descriptive analysis think about how we might continue this study to undertake a time series regression. What are the limitations of our analysis? What covariates would you consider? What potential biases would you consider? How might you structure your analysis?

APPENDIX

1. Using the Select using Map search option to find weather stations

A.1 Click the drop down option to review the available data.

A.2 The search bar allows for open ended searches by entering the name city, council or region you are interested in. Enter Liverpool into the search bar.
A.3 The search will provide you ‘towns’ that meet your search criteria. In the Matching Towns section select the first Liverpool.

A.4 By Selecting Liverpool the map will automatically zoom into the area around the town.

A.5 Click on your station of interest. Similar to the search by text option a histogram will appear below highlighting the time period and the completeness (%) of data for that station.

A.6 Double clicking the climate variable of interest will take you through the same page as step 4.3 in the search using text instructions.
Appendix B

Report to a non-scientific audience
“Gastro – everybody gets it at some point, but what is it?”, ACTive Play newsletter, June 2016
There is no specific treatment for viral gastroenteritis. General care recommendations include:

- The provision of plenty of fluids – oral rehydration solution is highly recommended for children with mild to moderate dehydration following diarrhoea and/or vomiting.
- Breastfeeding babies should continue to breastfeed throughout their illness wherever possible.
- Children on formula or solids should restart their normal diet following rehydration, however foods high in sugar or fat should be avoided.
- Medicines to prevent vomiting or diarrhoea should not be given (especially in children), except where specifically advised by a doctor.

It is important to see a doctor straight away if a child is not tolerating fluids, becomes listless or is not responding in their usual manner or if you are concerned about your child’s health.

_Okay, my child is starting to feel better now what?_

Viral gastroenteritis is most easily transmitted during the symptomatic stage of the disease; however the virus may be shed for some time after symptoms stop.

Children in childcare, preschool and school, and adults who work should be excluded from attending until they have had no diarrhoea for 24 hours. This exclusion period should also apply to swimming pools.

In adults who are food handlers or health care workers (including aged care) the exclusion period should extend until there has been no diarrhoea for 48 hours.

Good hand hygiene and cleaning practices should continue after illness to aid in the prevention of re-infection in the future.

_There has been an outbreak of gastro at our playgroup/child care centre, what now?_

Due to the highly infective nature of many ‘gastro’ causing viruses, outbreaks are common in childcare centres and aged care facilities and other closed settings including schools and hospitals. During outbreaks it is recommended staff and children with vomiting or diarrhoea stay away (are excluded) from the centre until they have had no diarrhoea for 48 hours.

Outbreaks of two or more cases of vomiting and/or diarrhoea in 24 hours should be notified to the Health Protection Service.

_I am feeling more comfortable about viral gastro, but what if I would like more information?_

For more information on viral gastroenteritis contact your doctor or call the Health Protection Service, Communicable Disease Control Information Line during business hours on (02) 6205 2155.

_Acknowledgment_

Information provided in this article is drawn from the ACT Health factsheet on Viral Gastroenteritis available:

http://www.health.act.gov.au/sites/default/files/actsheets/Viral%20Gastroenteritis%20Act%20Factsheet%20%0A14%0A45%0A.pdf
Keeping your child healthy – Viral gastroenteritis

‘Gastro’ – everyone gets it at some point, but what is it?

‘Gastro’ is a common occurrence in the lives of many young families, a rite of passage; clean, change, wash, repeat. Viral gastroenteritis, the most common cause of ‘gastro’ type illness in children, is an infection of the stomach and bowel that is usually characterised by symptoms of vomiting and diarrhoea. Nausea, abdominal pain, muscle aches, tiredness, headaches and low grade fevers are other symptoms caused by viral ‘gastro’, it is more common in winter, but affects both children and adults all year round. It is usually a mild illness and can be caused by a number of different common viruses such as norovirus and rotavirus.

Viral gastroenteritis is highly infectious! It is spread via the faecal-oral route through the contamination of hands, objects or food with infected faeces or vomit which is then taken in by the mouth. Touching surfaces or objects with these germs on them and putting your hands or fingers in your mouth is therefore a plausible and common mode of transmission. Transmission can also occur when virus particles remain in the air after a person vomits.

After ingesting the virus, symptoms usually take between one to three days to develop, but this period can be as short as 10 hours. The illness generally resolves on its own and typically lasts between one to two days.

Viral gastroenteritis is generally diagnosed based on a person’s symptoms. However, a faecal examination can sometimes identify the virus that is causing illness. You will need to see your GP to arrange a faecal test.

Now I know what it is, I don’t want it near my family

The most effective way of preventing viral gastroenteritis is to practice good hand hygiene. Good hand hygiene removes harmful microorganisms (germs) from our hands breaking the transmission chain between being exposed to a virus and becoming infected with the virus.

Washing hands properly with soap, preferably liquid, is the preferred method for the prevention of viral ‘gastro’. Using running water, you should wet your hands and thoroughly lather with the soap. Next, rub hands together for a minimum 10 seconds paying attentions to the backs of hands, wrists, between fingers and underneath fingernails. Rinse your hands well under running water and dry them preferably using disposable paper towel or a clean towel. It is particularly important for people who have had gastroenteritis and whose symptoms have resolved to keep their hands clean as people may remain infectious even after they appear to have recovered.

Hand washing should be done after using the toilet, after changing nappies, after assisting someone with diarrhoea/or vomiting and before preparing and eating food.

The wiping down of surfaces, particularly food preparation surfaces and play surface areas, is another effective way of reducing you and your children’s risk of infection. As a general rule, using a mild detergent with warm water in a mechanical action (i.e. wiping or scrubbing) is all that is required.

We got unlucky, what should I do if my child has viral gastroenteritis?

Firstly, a child who is unwell should not attend playgroup or child care centres so they do not spread the infection to others.
Report to a non-scientific audience

Health Bulletin, Volume 6, Issue 1, February 2017

ACT Population Health Bulletin

Volume 6  Issue 1  February 2017

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Upcoming Events

- 17 March 2017 - National Ride to School Day
- 17-24 March 2017 - Canberra Walks and Ride Week
- 19 May 2017 - National Walk Safely to School Day

A message from the ACT Chief Health Officer

This issue of the Bulletin is dedicated to a topic which affects us all – ageing. The demographic transition to longer life expectancy in early life and consequently longer life expectancy is one of the great success stories of population health and, more recently, of advances in health care. Compounding this trend to longer lives in the ACT is the relatively recent trend for our retirees to remain resident in the Territory, rather than to relocate elsewhere. It was previously the more common path. The result is that Canberra is growing older faster than the rest of Australia, at least from a demographic perspective. This has, in turn, led to some of our key population health challenges now and into the future: how can we maximise health and wellbeing in our ageing population? This is a public good in itself but also has the potential for large economic and social benefits, including savings in health service expenditure.

As we age, patterns of disease, hospitalisation and causes of death change. Whilst many illnesses become more prevalent with age, many are preventable or at least modifiable through health promotion and health promotion and preventative programs. Screening for certain cancers as well as early diagnosis of treatable conditions such as diabetes or the recognition of modifiable risk factors for both cardiovascular disease and cognitive decline are important for decreasing or at least delaying the burden of disease in this age group. Vaccination has benefits beyond the well known and important disease protection in childhood. For older Canberrans, influenza, pneumonia and Herpes zoster (shingles) vaccines are also recommended. Residents and staff of Aged Care Facilities are vulnerable to outbreaks of respiratory and gastrointestinal illness and ACT Health, in collaboration with facility management, have instilled novel and successful prevention and response programs in recent years across Canberra. For a variety of reasons the elderly are also particularly vulnerable to our warming climate and these will need to be specific adaptation and mitigation strategies in coming years during our increasingly warm summer months.

The main take home message from this issue of the Bulletin is that whilst ageing brings many health challenges, these challenges are not an inevitable result of the ageing process. In fact, the keys to healthy ageing share many similarities to achieving and maintaining good health at any age – eat well (and not too much), keep moving (and add some muscle strengthening exercises), stay socially connected, learn something new from time to time and be positive in your outlook. Each of these broad topics are covered in articles in this issue.

Thanks to our two guest editors, Paula Sutton and Ingrid Coote and to all the authors. A special thank you to Dr Sue Pakker for her positive and personal message on the health benefit of volunteering.

Dr Paul Kelly
ACT Chief Health Officer
February 2017
Appendix B

Article

Heat stress and ageing: staying safe in the heat

Samuel McEwen, Communicable Disease Control, Population Health Protection and Prevention

Heat and the Elderly

The elderly have a greater risk of mortality during heatwaves and periods of consistent excessive heat (35°C). The exacerbation of existing medical conditions and heat-specific related health events such as heat stress and heat stroke has been observed to result in increased hospitalizations and emergency department presentations in older age groups.12,13,14 The increased likelihood of adverse health events in the elderly in association with exposure to excessive heat is primarily a function of biological changes associated with age. Socio-economic and environmental factors also function as determinants of risk levels.

Compared to younger people, healthy older people have altered cardiovascular responses to heat stress.15 The lower limits of thermal tolerance in the elderly during passive heat exposure is expressed in an attenuated increase in cardiac output, in part due to a lack of ability to maintain stroke volume.16 During heat stress older people therefore rely on a greater percentage of their heart rate reserve to increase cardiac output.17 The increased cardiovascular strain and body’s demand for increases in myocardial oxygen, with a reduced increase in thermoregulatory skin blood flow, may prompt acute cardiovascular events in those with clinical or subclinical disease.18

The reduction in the ability to increase skin blood flow in response to heat stress with age limits the ability of the body to maintain core temperature during heatwaves.19 Along with reduced thermoregulatory skin blood flow, ageing is also associated with a decreased sweat rate and sweat output per gland.20 This results in greater heat storage in the elderly, which can also exacerbate cardiovascular strain in response to heat exposure. Although older people have reduced ability maintain body temperature by sweating, increased exposure to heat stress and prolonged sweating associated with exposure can cause a significant reduction in plasma volume.21 This reduction and additional changes in blood properties associated with reduced plasma volume contribute to increased susceptibility to acute coronary events and ultimately mortality.22

The increased biological susceptibility to heat results in an increased risk of acute coronary events, heat stroke/stroke and exacerbation of pre-existing morbidity and mortality among the elderly.

Heat waves and prolonged extreme heat conditions and the potential effect on health are frequently reported on in the media, in Australia and globally.

Following the 2003 European heat wave it was frequently reported in the media that the number of deaths attributable to the heat wave in the tens of thousands. France alone reported nearly 14,000 deaths during the heat wave period, the majority of which were observed in people aged over 70 years. Even after controlling for long-term and seasonal time trends with the usual effects of temperature and air pollution, a revised estimate still attributed 3,096 excess deaths to the heat wave. In 2010, in the northern-eastern Indian state of Gujarat, a heat wave was found to be associated with a 45.1 percent increase in all-cause mortality compared to a reference period of non-heat wave conditions.23 In India’s east, a heat wave was reported by The Times to have resulted in more than 2,300 deaths, primarily amongst elderly populations.24 A study of mortality displacement in London found the elderly had the greatest increase in excess deaths compared to younger counterparts.25 A review of extreme heat events in Australia over 10 years from 1844-2010 identified that extreme heat has resulted in more deaths than the sum of all other natural hazards, accounting at least 5,352 people to have died from extreme heat events in this period.26 Of these deaths, elderly were found to be significantly more vulnerable to the risk of heat-associated death than the general population.
Heat stress and ageing: staying safe in the heat (continued)

Staying safe in the heat

Considering the increased vulnerability of the elderly to extreme heat and acute events such as heat waves, it is important they are guided to act cautiously in hot weather. ACT Health advises that to reduce the risk of heat-related stress the elderly should:

1. Drink plenty of fluids and avoid dehydration:
   - Dehydration reduces the body’s ability to cool itself by sweating. Despite the decreased sweat rate and output per gland associated with ageing it is important to seek advice from medical professionals as to how much should be consumed, especially if the person is on limited fluids or fluid pills.
   - Water is the best fluid to drink.
   - Avoid beverages which are diuretic, namely beverages that contain caffeine or alcohol.

2. Stay in a cool environment:
   - Stay indoors or in the shade wherever possible.
   - Sleep in the coolest part of the home or apartment.
   - Keep air circulating and use conditioning if available. If air conditioning is not available at the residence, it should be considered to visit a air-conditioned facility, such as a shopping centre, library or aged care facility (living independently), or a family member who has air conditioning.

3. Reduce physical activity:
   - Avoid strenuous physical activity.
   - If activity is unavoidable, rest often and drink plenty of fluids.

4. Take extra measures to increase cooling:
   - Wear light-weight clothing.
   - Take a shower, bath or sponge bath.
   - Eat regular, light meals.

5. Have a plan or contacts in case:
   - Relatives or friends should frequently check in on sick or frail people who may need help in coping with the heat.

TIPS TO BEAT THE HEAT!

WATCH OUT

References


Appendix C

Oral presentation

ACT GOVERNMENT

An analysis of influenza trends using notification and test data in the ACT, 2005–2015
Samuel McEwen1,2, Aparna Lal2, April Roberts-Witteveen2, Marlena Kaczmarek1
1. Health Protection Service, Population Health, ACT Health, ACT
2. National Centre for Epidemiology and Population Health, Research School of Population Health, ANU College of Medicine, Biology and Environment, Australian National University, ACT

Background

↑ PCR & respiratory virus panel testing → ↑ count of positive tests
- Difficult to assess trends in notification surveillance of influenza over time

ACT Health receives test data from Lab A, to detect incidence trends

Methods

Data sources
- Lab B—primarily serves general practices (2005–2012)
- Laboratory confirmed notifications (2005–2015)

We compared two ACT based laboratories and notification data using negative binomial regression
Crude notification and test rates per 100 000 population with 95% CI and proportion of positive influenza tests (%), ACT, 2005–2015

Negative binomial regression

<table>
<thead>
<tr>
<th></th>
<th>Notification rate*</th>
<th>Positive test rate**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR</td>
<td>P-value</td>
</tr>
<tr>
<td>Laboratory B</td>
<td>0.98</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Reference: Laboratory A

*offset by Population (per 100 000), 2005-2015
**offset by number of tests (per 1000), 2005-2012
Summary

- Notification rates for influenza

IRR of positive tests at Lab B (GP) > Lab A (Hospitals)
- Influence of respiratory virus panel testing or screening?

Using data from one lab only to enhance flu surveillance → biasing/underestimating our interpretation of influenza incidence trends

The ACT would benefit from the routine reporting of negative tests from all laboratories

Acknowledgements

National Centre for Epidemiology and Population Health (NCEPH), Australian National University (ANU) supervisor - Dr Aparna Lal.

ACT Health, Communicable Disease Control Section (CDC) supervisors - Dr Marlena Kaczmarek, Rebecca Hundy, April Roberts-Witteveen

ACT Health, CDC & OCHO staff

National Centre for Epidemiology and Population Health (NCEPH), Australian National University

Both pathology providers
Questions
Appendix D

Outbreak investigations in the ACT
A case series analysis of gastroenteritis among a visiting school group to the ACT

Outbreak report & Introduction

On Friday 5 August 2016, the ACT ambulance service (ACTAS) notified the Health Protection Service of an outbreak of gastroenteritis. ACTAS reported that 20 students and a number of staff on a school camp, staying at an accommodation facility on the border of the ACT and New South Wales (NSW), were affected with gastroenteritis symptoms.

With the large number of sick students and staff, the school trip leader was concerned about the limited ability to care for the children. A clinical assessment team from Calvary was deployed to the hotel and the Community Service Directorate (CSD) was contacted to provide care support for students. CDC staff were deployed to provide infection control advice, personal protective equipment (PPE), and to undertake an epidemiological investigation by obtaining illness characteristics and food histories.


Methods

All ill students, parents/teachers and staff were interviewed. Cases were defined as anyone from the school group cohort, or any staff of the accommodation facility who had three or more loose stools and/or two or more episodes of vomiting within a 24-hour period. Cases were interviewed using a modified gastroenteritis food history questionnaire which included symptom, travel and contact histories, as well as demographic details.

Questionnaire data were captured and cleaned in Microsoft Excel to generate descriptive statistics and epidemiological curves by onset of illness by date and time.

Results

Twenty-seven students, five teaching staff and two accommodation facility staff reported illness meeting the case definition. The age range was 12 to 55 years, with a median age of 12 years. The index case reported onset of illness Wednesday, 3 August 2016, at 12:00pm. One other case was reported the same day. Nine cases reported onset Thursday, 4 August 2016, and 21 cases reported onset on Friday, 5 August 2016 (Figure 1). Two staff from the accommodation facility reported onset of illness Saturday, 6 August 2016 (Figure 1).
Outbreak investigations in the ACT

Vomiting was reported in 82.4% of cases (n=28) and diarrhoea reported in 48.5% of cases (n=16). Twenty cases (80%) reported nausea, nine (36%) reported fever, 14 (56%) reported chills, eight (32%) reported Muscle aches and pains, 14 (56%) reported headache and 17 (68%) reported fatigue. Five cases reported ‘other symptoms’, three reported sore throats, one reported dizziness and one reported ILI symptoms.

Duration of illness was calculated for 28 cases. Assuming last vomiting or diarrhoea as an indicator of cessation of illness, the median duration of illness was 9.5 hours. This figure is skewed by the accommodation staff, who reported duration of illness substantially longer than cases associated with the school group.

Follow-up with the cohort on Saturday 6 August 2016, identified no further cases were reported overnight, and that all cases had resolved as of 8:00 am. The commercial airline the group was booked with was advised in case of further secondary cases during travel and the group was cleared to depart and return to Brisbane.

Figure 1: number of cases by date and time of onset

Vomiting was reported in 82.4% of cases (n=28) and diarrhoea reported in 48.5% of cases (n=16). Twenty cases (80%) reported nausea, nine (36%) reported fever, 14 (56%) reported chills, eight (32%) reported Muscle aches and pains, 14 (56%) reported headache and 17 (68%) reported fatigue. Five cases reported ‘other symptoms’, three reported sore throats, one reported dizziness and one reported ILI symptoms.

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Discussion
Considering the frequency of school group travel to the ACT, it is important to be prepared for gastroenteritis outbreaks in these groups. The timely response to this outbreak coordinated between multiple health services within ACT, resulted in successful clinical and public health engagement. This highlights the resilience of the ACT Health system to respond to outbreaks of this nature and the capacity for different ACT government agencies to work together.

Following the investigation, a debrief was held to discuss the response to the outbreak. The focus of the debrief was to improve future public health practice by providing staff the opportunity to celebrate success, provide feedback and identify learning points. The outbreak used a standardized structured framework described by Dalton et al in a structured framework for improving outbreak investigation audits (1).

The debrief identified that one of the strengths of the outbreak response was the communication between the HPS and external stakeholders. These stakeholders included the accommodation facility and the school involved and also the clinical assessment team from Calvary Hospital Emergency Department and the CSD who deployed Red Cross volunteer services. For health sector stakeholders a recommendation to improve future public health action was to develop a standard operating procedure for engaging and deploying teams in outbreak scenarios. As a learning opportunity, the debrief identified that sending a mobile public health team from HPS to the accommodation enabled an accurate picture of the outbreak to be obtained. This allowed for additional resources to be delivered including personal protective equipment (PPE) and gastroenteritis kits in timely fashion. In addition, it provided a good frontline public health work experience for staff.

The case series outbreak investigation that was undertaken met its directive to establish the existence of an outbreak and to control the spread of infection. The multidisciplinary response highlighted the potential need for multiple expertise in outbreak responses. By undertaking a structured debrief the learnings from the investigation have been formalised into recommendations to improve future public health action.

All photographs presented in this Appendix are published with the permission of the subjects.
References


Appendix D

ACT Population Health Bulletin
Volume 5  Issue 3  August 2016

Introduction
A message from the Chief Health Officer

This issue of the Bulletin is devoted to one of the most successful and cost-effective of public health interventions, namely immunisation. To clarify terminology, the World Health Organization defines immunisation as the process whereby a person is made immune to an infectious disease, typically by the administration of a vaccine. Vaccination is the administration of antigenic material (a vaccine) to stimulate an individual's immune system to develop adaptive immunity to a pathogen. For the purpose of this issue, we have used the terms interchangeably. The topics covered include the history of immunisation, the role of surveillance including for adverse events related to vaccination and specific considerations for vaccination in specific populations or circumstances.

The ACT is in a unique position in Australia with our centralised approach to immunisation policy, vaccine purchasing, storage and delivery, education to providers and the public, monitoring and surveillance implemented by one section of the Health Protection Service. In terms of the administration of vaccines and reporting this is a true and successful partnership with clinicians in ACT Health and importantly with private health service providers in the community, notably general practitioners. In 2016, a new portal of access to influenza vaccination has become available with pharmacists authorised to vaccinate for influenza within pharmacies.

In the ACT, we are rightly proud of our record on immunisation as we are frequently the best performing jurisdiction in Australia. Similar to other states and territories, our challenges continue to be in the area of school-based and adult immunisation as well as reaching those who do not access vaccination services. This is largely a philosophical issue in Australia where personal agency in decision making that is broader community values are paramount considerations. The diseases which we are attempting to protect the population from are now rare and where vaccines are given equal exposure, notably on the internet and in social media. The long held view that decisions about vaccination should be based on the commercial benefit of preventing potentially life-threatening diseases in the community is now outweighed by the real or perceived risk of adverse events related to vaccination of individuals.

A successful immunisation program requires strong monitoring of performance, achieved through strong data collection systems and rigorous analysis of that data we collect. Through this surveillance, we can detect local challenges such as decreased vaccination rates in indigenous children and the emergence of new strains of illness not covered by current vaccines. The utility of the analysis of local data is demonstrated in several articles in this issue.

The future for immunisation is bright, but likely to become more complex. The National Immunisation Program continues to expand. New vaccines are continually being developed as well as new technologies for production and delivery systems which can revolutionise vaccination programs by providing easier, simpler delivery and more effective longer-lasting protection.

This issue would not have been published without the excellent work of Carolyn Banks who is the head of the immunisation section, guest editor and the author of several articles. Thanks also to the other contributors and as always to the editorial committee for their rapid and comprehensive editing and advice.

Dr Paul Kelly
ACT Chief Health Officer
August 2016
Outbreak investigations in the ACT

Hot Issues

Outbreak of gastroenteritis in a visiting school group: an example of a frontline public health response

Each year numerous school groups from around the country visit the Australian Capital Territory (ACT). Occasionally, particularly during the winter viral gastroenteritis season, these groups suffer from outbreaks propagated by person-to-person transmission. In unfamiliar settings, with often busy travel schedules, limited staffing resources and children away from home, gastroenteritis outbreaks in visiting school groups are potentially stressful and delicate situations that require special attention from local health services. Pared with the potential for outbreaks to spread into local communities and/or throughout ACT accommodation facilities and thereby result in pressure on our health services, a timely and coordinated response to these situations is required. In August 2016, ACT Health responded to an outbreak of gastroenteritis in a visiting school group at a popular tourist accommodation facility.

Initial notification

Early on 5 August 2016, the ACT Chief Health Officer (CHO) was notified of an outbreak of gastroenteritis by the ACT ambulance service, who received a call out to attend multiple “gastro” cases in a visiting school group. Twenty students and several teachers were reported to be unwell with vomiting and diarrhoea, out of a group of 60 students and 14 teachers and parent chaperones. Cases had been reviewed and provided oral hydration therapy; no children were hospitalised. The group, who had travelled from Brisbane, had spent time in the ACT and the New South Wales Snowy Mountains and was due to return to Brisbane on a commercial flight via bus to Sydney on Saturday 6 August 2016. Shortly thereafter, staff from the Communicable Disease Control Section (CDC) of the Population Health Division of ACT Health contacted the teacher in charge of the trip who reported that staff had limited capacity at that point to continue to care for the number of sick children, owing to illness and fatigue, and that further cases had developed since ACT Ambulance had attended overnight.

Response

The CDC took on a coordinating role for ACT Health in the management of this outbreak. By mid-morning a team consisting of an infection control officer, public health medical officers and epidemiologists attended the accommodation facility where the group was staying. They brought with them supplies of personal protective equipment for ACT Health staff as well as for the care for the children. The Executive of Calvary Public Hospital offered their support and the CDC requested a team of emergency room clinicians to provide further clinical assessment of cases on site. The Health Emergency Management Unit also contacted the ACT Community Services Directorate (CSD) to request assistance to relieve tired and sick staff members in caring for the children.

On arrival at the site, sick children and staff had been isolated from the rest of the group and the Calvary clinical team were already undertaking their clinical assessment. The CDC team began interviewing cases using a modified generic questionnaire, which included a food history for the previous three days, as well as a description of symptoms and time of onset. After several cases were interviewed, food histories and illness characteristics were assessed. Using this information, and in consultation with the Calvary clinical team, it was hypothesised that the likely cause of the outbreak was the likely source of a viral agent. Food histories were subsequently not continued for the remainder of cases. Data were captured and analysed using Microsoft Excel.

Infection control assessment was undertaken by the infection control officer, who liaised with management to ensure appropriate procedures were in place for environmental cleaning and laundry services. Healthy students and staff members were given an education session about correct hand washing technique and hand hygiene. It was established that the bus company transporting the group had robust infection control procedures in place.

The CSD deployed two staff and enlisted a volunteer from the Red Cross to assist with the care of students, providing valuable relief to the teaching staff. On Friday night, 5 August 2016, in response to a report of the onset of illness in a further five students and three teachers, Calvary Hospital, on request by the on-call CHO deployed an emergency department nurse to provide clinical assessment and assistance. No cases were hospitalised.

Image: HPS staff. ACT Health

A cohort study of gastroenteritis among attendees at a wedding and a barbeque breakfast

Outbreak report & Introduction

The contamination of food products by microbial pathogens is a major public health concern. It has been estimated in Australia, circa 2010, there were 4.1 million cases of foodborne gastroenteritis, responsible for approximately 25% of all cause gastroenteritis cases.¹ In 2000, the cost burden of foodborne gastroenteritis was estimated at 1.25 billion Australian dollars annually.² A 2010 review on foodborne illness in Australia, circa 2000 and 2010, estimated less than a quarter of suspected foodborne gastroenteritis cases identified the pathogen responsible for illness.¹ In cases of foodborne gastroenteritis where a pathogen was identified; pathogenic Escherichia coli, norovirus, Campylobacter spp., and nontyphoidal Salmonella spp. accounted for 93% of illness.¹

In the ACT foodborne illness is monitored through surveillance of notifiable conditions caused by common foodborne pathogens and self-reported suspected foodborne illness by the community or general practitioners on behalf of their patients. Where foodborne illness is suspected, the outbreak potential of many pathogens commonly associated with food contamination requires appropriate public health investigation.

On 15 March 2016, the Health Protection Service (HPS) was notified by email from an ACT-based general practitioner (GP) of a cluster of suspected foodborne gastroenteritis. The GP reported multiple persons with gastroenteritis symptoms following a wedding held on 12 March at a function venue in the ACT, and a privately catered barbeque breakfast associated with the wedding, held on Sunday 13 March in the ACT. The GP reported at least 8 people who attended the wedding and/or barbeque suffering from acute gastroenteritis. An investigation was initiated with the aim of confirming the existence of an outbreak, finding and characterising cases, identifying the aetiological agent and source of infection, and implementing control interventions to prevent further illness or ongoing public health risk.
Methods

Epidemiological investigation

A cohort study was designed to investigate the outbreak. The cohort was defined as those persons who attended either or both, of the wedding and barbeque breakfast. Study participants were contacted by phone and interviewed using a modified standardised questionnaire (supplementary material) which included food items potentially consumed at the wedding and/or the barbeque breakfast, as well as symptoms, time of onset, and travel details. A list of attendees was obtained from the bride and groom, and all attendees were attempted to be contacted a maximum of six times within a five day period. After this point attendees were considered lost to follow-up. Attendees who were contacted but declined to take part in the study were also considered lost to follow up and excluded in analysis.

A list of food items on the menu from the wedding was obtained from the bride and groom and confirmed by the venue. A list of available food items for the barbeque breakfast was attained from interviewing the bride and groom who held the function.

A suspected case was defined as any person who attended either or both the wedding at the Venue X on Saturday 12 March and the barbeque breakfast held at the Sport Club Y on Sunday 13 March; and had:

Three or more loose stools or bowel movements in a 24 hour period that are different from normal

AND/OR

Two or more episodes of vomiting in a 24 hour period.

Cases were excluded if they reported symptoms which had a known alternative cause of illness, such as past history of bowel disease, excessive alcohol consumption or pregnancy.

Questionnaire data were captured in Microsoft Excel and cleaned using Stata IC v14 (StataCorp LP, College Station, TX). Univariate and stratified analysis were conducted using STATA 14 to calculate relative risk with 95% confidence intervals (CI) and p values (less than 0.05 considered significant).
Environmental investigation

An Inspection of the wedding venue was conducted by public health officers (PHO) on 17 March 2016. All food at the wedding was prepared and served by venue staff. The environmental investigation did not identify any issues surrounding food preparation or storage. No food samples were collected or submitted to the ACT Government Analytical Laboratory (ACTGAL) for testing.

Laboratory investigation

Faecal samples were requested from cases, where appropriate (still symptomatic or recently recovered). Specimen sample pots were provided to those willing to submit a specimen with pathology requests for microscopy, culture and sensitivity testing and viral studies. One case submitted a specimen; however, the sample was urine, not faecal, and therefore unable to be of use in the investigation.

Results

Epidemiological investigation

A total of 82 guests attended the wedding on Saturday 12 March, 40 of which also attended the barbeque breakfast the following morning. The bride and the groom provided names and contact details of 74 (92.5% of guest) guests for attempted interview. Sixty interviews (81% of guests whose details were provided) were completed with 14 attendees lost to follow up, of which two declined interview. All attendees (n=40) who attended both the wedding and the barbeque were interviewed.
Outbreak investigations in the ACT

Illness was characterised by diarrhoea (100%), fatigue (100%), nausea (84%), vomiting (77%), and abdominal cramp (77%). No cases were admitted to hospital and no deaths were identified. At the time of interview two cases had visited doctors for their illness. No specimen was collected at either consultation.

Illness onset ranged from midnight 12 March (night of wedding) to 2200, 14 March 2016 (Figure 2), with a median incubation period of 32 hours from last possible exposure at the Wedding on 12 March at 2300; and, 23.5 hours from last possible exposure to barbeque breakfast (excluding one case with onset prior to BBQ). The median length of illness was 17 hours with a range of 9-72 hours.

Comparison of participants by age and sex revealed no significant statistical difference among those who reported illness (Table 1). The median age of well attendees who attended either of both the wedding and the barbeque was 29 years (range 23–74 years). In cases the median age was also 29 years (range 25–74 years). The male to female ratio for cases was 1:1.3 who attended either or both the wedding and the barbeque was and 1:1 among non-cases.

Figure 2: Number of cases by date of onset & function attendance

Illness onset ranged from midnight 12 March (night of wedding) to 2200, 14 March 2016 (Figure 2), with a median incubation period of 32 hours from last possible exposure at the Wedding on 12 March at 2300; and, 23.5 hours from last possible exposure to barbeque breakfast (excluding one case with onset prior to BBQ). The median length of illness was 17 hours with a range of 9-72 hours.

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Table 1: Case description, demographic and event exposure comparison of participants enrolled in cohort study by illness status.

<table>
<thead>
<tr>
<th></th>
<th>Case</th>
<th>Non case</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>count</td>
<td>%</td>
<td>count</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>5</td>
<td>38%</td>
<td>22</td>
</tr>
<tr>
<td>Male</td>
<td>8</td>
<td>62%</td>
<td>25</td>
</tr>
<tr>
<td>Age: mean (± SD)</td>
<td>28 (15.4)</td>
<td>29 (14.0)</td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>20-29</td>
<td>9</td>
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<td>29</td>
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<td>30-39</td>
<td>2</td>
<td>15%</td>
<td>8</td>
</tr>
<tr>
<td>40-49</td>
<td>0</td>
<td>0%</td>
<td>0</td>
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<tr>
<td>50-59</td>
<td>1</td>
<td>8%</td>
<td>7</td>
</tr>
<tr>
<td>60-69</td>
<td>0</td>
<td>0%</td>
<td>2</td>
</tr>
<tr>
<td>≥70</td>
<td>1</td>
<td>8%</td>
<td>1</td>
</tr>
</tbody>
</table>

Univariate analysis of potential food exposures during the wedding among the cohort of wedding attendees (n=60) did not reveal any statistically significant associations between food served at the wedding and illness. Honey marinated chicken (RR 3.0 CI 0.43–20.86 \( P > 0.05 \)) and porterhouse steak (RR 0.92 CI 0.34–2.42 \( P > 0.05 \)) were the two mains served at the wedding. Over half, 60% of guests and 77% of cases, reported consuming, some or all, of both mains. The consumption of honey marinated chicken was stratified by the consumption of porterhouse steak to identify if there was any significant increased relative risk of illness when consumption of one or the other main was considered independently. No significant association was found (data not shown).

Attending the barbeque following the wedding was associated with increased risk of illness (RR 6.0 95% CI 0.84–42.94 \( P < 0.05 \)) that was significant at \( P < 0.05 \), however had a wide confidence interval that crossed the null. As the relative risk was large and showed a significant p value, univariate analysis was conducted for the cohort of people who attended the breakfast. There was no statistically significant association between and food exposure and illness in guests who attended the breakfast (n=40). The consumption of egg by itself had the largest relative risk (Table 3) but was not statistically significant (\( P > 0.05 \)) despite the confidence interval not crossing the null (CI 2.15–5.85). The frequency of consumption of egg by itself was
however low (n=1) and the interpretation of this result, even if significance was identified, would be limited.

Table 2: Univariate analysis of risk factors for foodborne illness following a wedding

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Exposed</th>
<th>Unexposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Cases</td>
</tr>
<tr>
<td>Barbeque</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>Honey marinated chicken</td>
<td>48</td>
<td>12</td>
</tr>
<tr>
<td>Potato salad</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td>Mixed green leaf salad</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>Sausage rolls</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>Sweet chilli pork meatballs</td>
<td>43</td>
<td>10</td>
</tr>
<tr>
<td>Fried zucchini</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>Steamed carrots</td>
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<td>8</td>
</tr>
<tr>
<td>cauliflower</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>Ribbon sandwiches</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>Porterhouse steak</td>
<td>47</td>
<td>10</td>
</tr>
<tr>
<td>Baby rocket salad</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>Mini hotdogs</td>
<td>42</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3: Univariate analysis of risk factors for foodborne illness following a barbeque after a wedding

<table>
<thead>
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<th>Exposure</th>
<th>Exposed</th>
<th>Unexposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Cases</td>
</tr>
<tr>
<td>Egg – by itself</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Used bathroom</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>Grapes</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>strawberry</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
The use of the bathroom facility at the breakfast venue (RR 1.89) was also considered in the univariate analysis to seek any potential association between bathroom use and illness. The increased relative risk for bathroom use however was not statistically significant (CI 0.45-7.90 $P>0.05$). Univariate analysis of the food items with positively associated relative risks and attack rates above 30% in those exposed, were stratified against bathroom usage, despite no significance found with any food items (Table 4). After stratification neither consumption of egg by itself, grapes or strawberries were found to have relative risks that were statistically significant (Table 4). The attack rate of strawberries however increased from 25% in those who ate strawberries and did not use the bathroom to 43% among those who ate strawberries and did use the bathroom. This was reflected in the relative risk between those who did not use the bathroom and ate strawberries (RR 0.85 CI 0.13-5.41 $P>0.05$) and those who did use the bathroom and ate strawberries (RR 1.29 CI 0.43-3.11 $P>0.05$). These findings are not statistically significant however and cannot be interpreted with confidence.

Table 4: Stratified univariate analysis to identify epidemiologic associations between specific food items available to people attending the barbecue.

<table>
<thead>
<tr>
<th></th>
<th>Exposed</th>
<th></th>
<th>Unexposed</th>
<th></th>
<th>RR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Cases</td>
<td>AR%</td>
<td>Total</td>
<td>Cases</td>
<td>AR%</td>
<td></td>
</tr>
<tr>
<td>No bathroom use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg – by itself</td>
<td>0</td>
<td>0</td>
<td>.</td>
<td>21</td>
<td>6</td>
<td>28.57</td>
<td>.</td>
</tr>
<tr>
<td>Grapes</td>
<td>8</td>
<td>3</td>
<td>37.50</td>
<td>13</td>
<td>3</td>
<td>23.00</td>
<td>1.62 [0.43-6.18]</td>
</tr>
<tr>
<td>strawberry</td>
<td>4</td>
<td>1</td>
<td>25.00</td>
<td>17</td>
<td>5</td>
<td>29.41</td>
<td>0.85 [0.13-5.41]</td>
</tr>
<tr>
<td>Bathroom use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg – by itself</td>
<td>1</td>
<td>1</td>
<td>100.00</td>
<td>27</td>
<td>9</td>
<td>33.33</td>
<td>3.00 [1.76-5.11]</td>
</tr>
<tr>
<td>Grapes</td>
<td>13</td>
<td>5</td>
<td>38.46</td>
<td>15</td>
<td>5</td>
<td>33.33</td>
<td>1.15 [0.43-3.11]</td>
</tr>
<tr>
<td>Strawberry</td>
<td>7</td>
<td>3</td>
<td>42.86</td>
<td>21</td>
<td>7</td>
<td>33.33</td>
<td>1.29 [0.43-3.11]</td>
</tr>
</tbody>
</table>
During interviews wedding attendees reported the banana, grape and strawberry being served together on a fruit platter. A variable for “fruit” was created during analysis that considered exposure as anyone who had eaten or a combination of banana, grape or strawberry. No statistically significant association between any fruit consumption and illness was observed (RR 1.8 CI 0.42–7.59 P>0.05). Additionally, when stratified by bathroom use no statistically significance associations were observed and attack rates in those exposed to fruit we similar between those who used the bathroom and those who did not (40% and 41% respectively).

**Environmental investigation**

The environmental investigation did not identify any issues surrounding food preparation or storage. Minor non-compliances regarding a lack of a probe thermometer in the kitchen to check temperatures and hand washing facility not properly stocked with soap or paper towel to facilitate correct hand washing were reported. An improvement notice was issued to the premise to rectify these issues. No staff were reported to be ill either on the day of the wedding or in the week prior to the wedding. As the barbeque was self-catered the venue where the barbeque was held was not inspected by PHOs. No food served at the barbeque was left over to be available for testing.

**Discussion**

We report a small outbreak of gastroenteritis of unknown aetiology following a wedding and an associated self-catered barbeque breakfast. Univariate and stratified univariate analysis identified no significant association between illness and food items consumed at either function for cases who attended either or both functions. Guest attendance at the barbeque, however, was significantly associated (at P<0.05) with illness (RR 6.0 CI 0.84 – 42.94 P<0.05). A wide confidence interval that crosses the null however suggests the result should be interpreted with caution. The environmental investigation of the wedding venue identified minor non-compliances regarding hand sanitation facilities and identified no issues in food preparation safety and storage procedures. No food samples were available for microbiological testing.

The median incubation time from either latest possible exposure to the wedding (32 hours) or the barbeque (23.5 hours) fit within biological plausibility of common bacterial (*salmonella spp*. or *campylobacter spp.*) or viral (norovirus, rotavirus) pathogens.\(^3\) We may underestimate incubation periods by a factor of hours as the exact time of food consumption
was not ascertained from cases. Illness was characterised by diarrhoea and fatigue in all cases and nausea, vomiting and abdominal cramps in greater than three quarters of cases. The short median duration of illness (17 hours), the median incubation periods not exceeding 36 hours combined with the frequency of vomiting as a symptom, all support norovirus as a plausible aetiological agent.

Norovirus is a common viral cause of gastroenteritis in the community and is highly infectious, often spread by person-to-person transmission.\textsuperscript{4, 5} This may explain the lack of association between food and illness observed in both cohorts. Although person-to-person transmission causes the majority of norovirus outbreaks,\textsuperscript{4, 6} contaminated food and water are also important modes of transmission.\textsuperscript{7, 9} Person-to-food-to-person transmission has also been reported in foodborne outbreaks of norovirus.\textsuperscript{10, 11}

In Australia, the OzFoodNet surveillance network is responsible for the active surveillance of gastrointestinal and foodborne illness.\textsuperscript{12} In 2011, OzFoodNet reported 79\% of all gastrointestinal outbreaks reported were likely caused by person-to-person transmission.\textsuperscript{13} Of these outbreaks, norovirus was the most common cause of illness accounting for 43\% of outbreaks.\textsuperscript{13} Although only 5\% of outbreaks of foodborne disease or suspected foodborne disease, were attributed to norovirus, in 31\% of outbreaks the aetiology of disease causing pathogen was unknown and the contribution of norovirus to foodborne outbreaks of gastrointestinal illness is underestimated.\textsuperscript{13}

**Limitations**

Our investigation has several limitations. The study was carried out approximately one week after exposure and thus we were reliant on recalled information available. Although a menu from the wedding was available, mains and sides were served buffet style, as was the barbeque breakfast. Considering the open choice of a variety of food options, recall bias is a possibility, as those who were unwell might have been more specific in their recollection of foods consumed at either event. This may have led to non-differential misclassification of exposure, and subsequently underestimation of the observed relative risks. A standardised questionnaire was used based on the menu provided by the wedding venue and a menu generated by recall from the barbeque organisers with no open ended questions was generated in attempt to limit these biases.
The size of the cohort study may have affected the ability to generate enough statistical power to detect associations between exposures and illness. Only a maximum of 73% of the full cohort was interviewed and included in the analysis. However, if the agent of infection was spread by person-to-food-person transmission any epidemiologic association between foods would be difficult to find. In addition, the design of the study did not lend itself to identify exposures indicative of person-to-person transmission.

Finally, no test for any microbial agents of gastroenteritis infection was undertaken on food items or environmental samples and no cases submitted a faecal specimen for testing. Although highly sensitive and specific nucleic acid testing for Norovirus is now readily available at the majority of public health laboratories and commercial pathology providers in Australia. The short duration of illness which characterises Norovirus may reduce the likelihood that cases seek medical care which was a likely factor in our investigation.4, 14, 15

**Conclusion**

A retrospective cohort study found no association between illness and any exposure to any food item. The epidemiological characteristics of cases suggest norovirus was the likely agent of infection.16 Norovirus is the most common pathogen responsible for gastroenteritis outbreaks through person-to-person transmission, which make up the majority of gastroenteritis outbreaks in Australia.13 It is plausible given the epidemiological and environmental investigation evidence to hypothesise person-to-person transmission was the cause of this outbreak. Without identifying either a source or agent of infection it is difficult to assess future public health risk. The limitations of epidemiological investigations to identify the agent of illness highlights the importance of collection of stool specimens to be given high priority in the investigation of community reported outbreaks of acute gastroenteritis. Especially in scenarios in which exposure to common food sources among cases occurs.
References

(n) 14. Lopman B. Norovirus: Simple Detection for Complex Epidemiology Clinical Infectious Disease. 2006;42(1 April):970-1.
Supplementary material

**SUSPECTED EVENT OUTBREAK**

**EVENT DETAILS**

<table>
<thead>
<tr>
<th>Interviewer Initials:</th>
<th>Date &amp; time Interviewed?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

**CALL INTRODUCTION**

Hi, my name is……………….. and I’m calling from …………………….

We are investigating a possible outbreak of foodborne disease. The reason for this investigation is to identify the source so we can prevent illnesses in the future.

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

Do you have time today to speak with me?  □ Y  □ N (if no, reschedule)

Before continuing with the interview, can I ask if you attended a wedding on Saturday 12 March and/or a private breakfast function associated with the wedding on Sunday 13 March

- □ Yes, I attended the wedding only (skip Q5)
- □ Yes, I attended the breakfast only(skip Q4)
- □ Y es, I attended both the wedding & the breakfast
- □ No, I did not attend either (finish)

**CASE DETAILS**

<table>
<thead>
<tr>
<th>First Name:</th>
<th>Last Name:</th>
<th>Parent’s Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(if applicable):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DOB:</th>
<th>Age:</th>
<th>Gender: □ M □ F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Address:</th>
<th>Home Phone:</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mobile Phone:</th>
<th>Email:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Clinical & Diagnostic Information

"We would like to obtain some detail on whether or not you became sick, and if so, what kind of symptoms you experienced & whether you sought medical care.

1. Have you experienced any illness after attending the wedding on Saturday 12/03/2016 or the associated breakfast function on Sunday 13/03/2016?

☐ Y ☐ N  if no please skip to Q2

If yes, complete table below

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Onset date</th>
<th>Onset Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vomiting</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Stomach Cramps</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Blood in stool</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Nausea</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Fever</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Chills</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Muscle and body aches</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Headache</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Fatigue</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
<tr>
<td>Other Symptoms</td>
<td>☐ Y ☐ N</td>
<td>☐ DK</td>
</tr>
</tbody>
</table>

If yes, how long did symptoms last (in hours) …….

If yes, how long did symptoms last (in hours) …….

If Yes, Temperature recorded °C ☐ DK / temp not taken

If yes. Specify
2. OTHERS WITH ILLNESS

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you see/hear about anyone who had symptoms of gastroenteritis <strong>before</strong> the function?</td>
<td>☐ Y ☐ N</td>
<td></td>
</tr>
<tr>
<td>Did you see/hear about anyone who had symptoms of gastroenteritis <strong>while at</strong> the function?</td>
<td>☐ Y ☐ N</td>
<td></td>
</tr>
<tr>
<td>Did you see/hear about anyone who had symptoms of gastroenteritis <strong>after</strong> the function?</td>
<td>☐ Y ☐ N</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone contact</th>
<th>Onset date and time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. TRAVEL AND ACCOMMODATION

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you have to travel and stay overnight for this function?</td>
<td>☐ Y ☐ N</td>
<td>If no, skip to Q4.</td>
</tr>
<tr>
<td>When did you arrive for the function?</td>
<td>Date / Time</td>
<td></td>
</tr>
<tr>
<td>When did you leave?</td>
<td>Date / Time</td>
<td></td>
</tr>
<tr>
<td>Where did you stay?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. WEDDING MENU

*I'm now going to go through the menu please let me know what you had to eat while at the function.*

<table>
<thead>
<tr>
<th>CANAPES</th>
<th>Food eaten by respondent?</th>
<th>Extra Details:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet chili pork meatballs</td>
<td>☐ Y ☐ N ☐ DK</td>
<td></td>
</tr>
<tr>
<td>Ribbon sandwiches (filling unknown)</td>
<td>☐ Y ☐ N ☐ DK</td>
<td></td>
</tr>
<tr>
<td>Spicy Homestead sausage roll</td>
<td>☐ Y ☐ N ☐ DK</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

5. BREAKFAST MENU

I'm now going to go through the menu please let me know what you had to eat while at the function.

<table>
<thead>
<tr>
<th>BREAFAST</th>
<th>Food eaten by case?</th>
<th>Extra Details:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muesli</td>
<td>□ Y □ N □ DK</td>
<td></td>
</tr>
<tr>
<td>Vanilla Yoghurt</td>
<td>□ Y □ N □ DK</td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td>□ Y □ N □ DK</td>
<td></td>
</tr>
</tbody>
</table>
### Outbreak investigations in the ACT

<table>
<thead>
<tr>
<th>Food Item</th>
<th>Y</th>
<th>N</th>
<th>DK</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strawberries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacon (by itself)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg (by itself)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you eat a bacon and egg roll</td>
<td>Y</td>
<td>N</td>
<td>DK</td>
<td>If yes, specify how egg cooked eg. Runny</td>
</tr>
<tr>
<td>With sauce</td>
<td></td>
<td></td>
<td></td>
<td>If yes specify</td>
</tr>
<tr>
<td>With any food items not mentioned</td>
<td>Y</td>
<td>N</td>
<td>DK</td>
<td>If yes specify</td>
</tr>
<tr>
<td><strong>DRINKS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juice</td>
<td></td>
<td></td>
<td></td>
<td>If yes specify.</td>
</tr>
<tr>
<td>Coffee</td>
<td></td>
<td></td>
<td></td>
<td>If yes specify.</td>
</tr>
<tr>
<td>Tea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td>If yes specify.</td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td></td>
<td></td>
<td>If yes specify.</td>
</tr>
</tbody>
</table>

**Additional Notes:**

---

Did you eat any other food item(s) not included on the list?  □ Y □ N □ DK

Did you use the bathroom at the Tennis club during breakfast?  □ Y □ N □ DK

Any other comments?
Appendix D

How long did it take to complete this interview?

Completed by: ………………………………………………………………………………………………………

<table>
<thead>
<tr>
<th>Public Health Officer Name</th>
<th>Time</th>
<th>Date</th>
</tr>
</thead>
</table>

Thank you for taking time to complete this questionnaire. If you have any questions please call 6205 2155 (or other interviewer specific number)

**To return the completed questionnaire:**

1. Email to: sam.mcewen@act.gov.au (or other interviewer specific email)
2. Fax to: 6205 1739