Applied Epidemiology of Communicable Disease at a National Level

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Field Supervisors:
Ms Rhonda Owen, Ms Cindy Toms and Dr Jennie Hood

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Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution.

Amy Burroughs 06/10/2017
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I have been very fortunate through my MAE to have wonderful supervision from Dr Kathryn Glass. Thank you Katie for being so quick to review my work and for always finding time to chat about methodologies and stats. I don’t think I could have handed in on time without your help! I have had a number of field supervisors throughout the two years (Ms Rhonda Owen, Ms Cindy Toms and Dr Jennie Hood) and they have all provided very useful input into my projects. I am particularly thankful to Rhonda for supporting my trip to WPRO; not all students can be so lucky. Thanks to Associate Professor Martyn Kirk for his support and for keeping me in mind for opportunities like WPRO and presenting at the AEA MAE day.

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Thanks to members of the NBBVSTI SSC, NISC, the Kimberley CA-MRSA Steering Group and CDNA for allowing me to present my work to you and for providing input into my projects. I learnt a lot about epi from simply sitting in on teleconferences.

Thanks to my family and my love Andreas for understanding (or at least accepting) the fact that I put myself through writing another thesis. This is the last one I swear!

Last but certainly not least, thanks to the MAE 2015 cohort. It was always so wonderful to meet up at ANU each year to share stories and give support. We almost feel like a little family and I’m excited to hear where everyone ends up and what exciting adventures lay ahead for us. Special mention to the Canberra Crew: Sam Siripol, Alex Marmor, Cecilia Xu and Paul Dutton - our lunch dates were essential to our mental health and I really value the friendships we forged.
Abstract

The Vaccine Preventable Diseases Surveillance section of the Australian Government Department of Health uses national data to monitor, analyse and report on a number of communicable diseases. Functions of the section include providing advice to inform policy, developing national pandemic plans, and providing epidemiological information to national and international stakeholders, including the Communicable Diseases Network Australia (CDNA). In this thesis, four epidemiological projects are described that utilize national data and state- and territory- specific data shared with the Commonwealth through professional networks. These projects identify populations at risk for certain communicable disease, identify gaps in national surveillance and make recommendations to improve the utility of surveillance data to better inform policy and public health interventions.

Chapter Two describes an epidemiological analysis of national notifications of infectious and congenital syphilis over the period 2006 to 2015. Trends in rates over time are compared between Aboriginal and Torres Strait Islander people and non-Indigenous people and the analysis determines the impact that an ongoing multijurisdictional outbreak of infectious syphilis affecting Aboriginal and Torres Strait Islander people in the northern parts of Australia has on state-specific and national rates. Information gaps in national surveillance data are identified, particularly for cases of congenital syphilis and a proposal for the inclusion of additional fields to better understand risk factors for congenital syphilis infections is developed.

Chapter Three describes the evaluation of the Australian Sentinel Practice Research Network (ASPREN); a national network of primary care practitioners that report on influenza-like illness. System data and the opinions of key stakeholders are used to evaluate whether ASPREN is achieving the objectives set for the system by the funding body, the Australian Government Department of Health. Recommendations are made to improve the representativeness, simplicity, sensitivity, and usefulness of ASPREN syndromic and virological data. Representativeness of syndromic surveillance sites is identified as necessary for the collection of meaningful data but is often challenging to achieve.

Chapter Four describes an epidemiological analysis of notifications of community-associated Staphylococcus aureus (CA-MRSA) infections in the Kimberley, Western Australia; an emerging public health issue in this region. The analysis utilizes a dataset that links individuals with a positive isolate to hospital and emergency department records over the period 2003 to 2015. The burden of CA-MRSA infections on the health care system is described and the analysis shows the very high rates of notifications for Aboriginal and Torres Strait Islander persons.
Chapter Five describes an investigation into an outbreak of acute gastroenteritis at a catered lunch event in the Australian Capital Territory. Although this cohort study does not identify the cause of the outbreak, key learnings from the experience are reflected upon. Chapter Six describes my experience conducting event-based surveillance at the World Health Organization’s Western Pacific Regional Office in Manila.

Additionally, this thesis includes examples of where epidemiological information is presented as part of teaching exercises to colleagues (Chapter Seven) as well as to national and international stakeholders, including CDNA and at national and international conferences.
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<tr>
<td>ANU</td>
<td>Australian National University</td>
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<tr>
<td>ASPREN</td>
<td>Australian Sentinel Practice Research Network</td>
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<tr>
<td>ACT</td>
<td>Australian Capital Territory</td>
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<tr>
<td>CA-MRSA</td>
<td>Community-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
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<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<td>CNDA</td>
<td>Communicable Diseases Network of Australia</td>
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<tr>
<td>DoH</td>
<td>Australian Government Department of Health</td>
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<tr>
<td>ED</td>
<td>emergency department</td>
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<tr>
<td>GP</td>
<td>general practitioner</td>
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<tr>
<td>HA-MRSA</td>
<td>healthcare-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
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<tr>
<td>ICD-10-AM</td>
<td>The International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification</td>
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<tr>
<td>IHR 2005</td>
<td>International Health Regulations (2005)</td>
</tr>
<tr>
<td>ILI</td>
<td>influenza-like illness</td>
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<tr>
<td>MAE</td>
<td>Master of Philosophy (Applied Epidemiology) program</td>
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<tr>
<td>MRSA</td>
<td>methicillin-resistant <em>Staphylococcus aureus</em></td>
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<td>MSM</td>
<td>men who have sex with men</td>
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<tr>
<td>NBBVSTI SSC</td>
<td>National Blood-borne Viruses and Sexually Transmissible Infections Surveillance Sub-committee</td>
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<tr>
<td>NCEPH</td>
<td>National Centre for Epidemiology and Population Health</td>
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<td>NISC</td>
<td>National Influenza Surveillance Committee</td>
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<tr>
<td>NNDSS</td>
<td>National Notifiable Diseases Surveillance System</td>
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<tr>
<td>NSW</td>
<td>New South Wales</td>
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<td>NT</td>
<td>Northern Territory</td>
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<tr>
<td>OHP</td>
<td>Office of Health Protection</td>
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<tr>
<td>PVP</td>
<td>predictive value positive</td>
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<td>abbr</td>
<td>full form</td>
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<tr>
<td>Qld</td>
<td>Queensland</td>
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<td>SA</td>
<td>South Australia</td>
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<td>Tas</td>
<td>Tasmania</td>
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<tr>
<td>Vic</td>
<td>Victoria</td>
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<tr>
<td>VPDS</td>
<td>Vaccine Preventable Diseases Surveillance</td>
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<tr>
<td>WA</td>
<td>Western Australia</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WHO CC</td>
<td>World Health Organization Collaborating Centre for Reference and Research on Influenza</td>
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<tr>
<td>WPRO</td>
<td>Western Pacific Regional Office</td>
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<tr>
<td>WO</td>
<td>Watch Officer</td>
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CHAPTER 1  GENERAL INTRODUCTION

1.1  FIELD PLACEMENT

My field placement commenced on 16 February 2015 in the Vaccine Preventable Disease Surveillance (VPDS) section within the Office of Health Protection (OHP) Division of the Australian Government Department of Health (DoH). The VPDS section is responsible for monitoring, analysing and reporting on vaccine preventable disease and some bacterial, blood-borne and sexually-transmissible infections. The section provides advice to inform policy on vaccines and pandemic planning, relevant information on VPDs to national and international stakeholders, and epidemiological advice to the Communicable Disease Network Australia (CDNA). My field supervisor was the Director of VPDS; initially Ms Rhonda Owen, then Ms Cindy Toms and then Dr Jennie Hood. Supervision and mentorship was provided for each project by section epidemiologists Ms Amy Bright (syphilis), Ms Christina Bareja (influenza), Dr Rachel de Kluyver (influenza) and Ms Kate Pennington (influenza).

In addition to the core MAE requirements, I contributed to the routine work of the VPDS section. This included extracting and analysing data for and writing several fortnightly Communicable Disease Surveillance reports and the syphilis section of the 2014 National Notifiable Diseases Surveillance System (NNDSS) Annual Report. Also, approximately once a month for 12 months I performed the role of Watch Officer (WO) which involved acting as the National Focal Point (NFP) for Australia during office hours; fulfilling Australia’s obligations under the International Health Regulations 2005 (IHR 2005). The WO is responsible for receiving incoming communications from international NFPs and state health departments regarding notifications of diseases of international public health concern and relaying this information to relevant NFPs and contact points for their action. I was trained in contact tracing, particularly how to identify contacts of communicable disease events on aircraft through passenger seat allocation lists (PSALs) and how to obtain contact details of these passengers through incoming passenger cards (IPCs) provided by the Department of Immigration and Border Protection.

Outside of my field placement at DoH, I had the opportunity to assist Ms Laura Ford (OzFoodNet epidemiologist) with an outbreak investigation at Australian Capital Territory (ACT) Health which is detailed in Chapter 5. I was also very fortunate to be given the opportunity to work as a Rumour Surveillance Officer at the World Health Organization (WHO)’s Western Pacific Regional Office (WPRO) in Manilla, Philippines. My experience at WPRO is described in Chapter 6.
1.2 OVERALL EXPERIENCE

Practicing epidemiology at a national level comes with many benefits but also some challenges that may differ to those experienced by students placed in state/territory health departments. In my opinion, the greatest benefit of working at a national level is the access to surveillance data for Australia via the NNDSS. This system provides a rich source of data for more than 50 communicable diseases or disease groups. I now understand that the objectives of conducting surveillance nationally are usually different to those at a state/territory level. Epidemiologists at the DoH are able to access these data in order to obtain a national picture of disease trends. This allows the reporting of information back to state/territory health departments, to policy makers and to international stakeholders such as the WHO. Multijurisdictional outbreaks may be detected through these means – where state/territory-based surveillance systems may not have the complete information available to make connections to similar disease events happening in other jurisdictions. Another benefit to working at the DoH is the strong interaction with CDNA and CDNA sub-committees. I learnt a lot of epidemiological concepts and methods through sitting-in on and participating in teleconferences and meetings with CDNA, the National Influenza Surveillance Sub-Committee (NISC), and the National Blood-borne Virus and Sexually Transmissible Infections Sub-Committee (NBBVSTI SSC). I had the opportunity to present project proposals and project outcomes to CDNA, NISC and NBBVSTI SSC where valuable feedback was given by members.

One challenge of working at a national-level is the separation you have from what is happening ‘in the field’ and the difficulty in putting your work into context. It is not always easy to understand the implications that suggested improvements to surveillance may have on those who have to actually go out and collect the data. This is why engagement with CDNA and the sub-committees is so important; to gauge the feasibility of any conclusions or recommendations you may make in epidemiological projects. Related to this challenge is the difficulty for students based at the DoH to get involved in outbreak responses in a timely manner. I was very fortunate as during my time at DoH, a working relationship was set up between DoH MAE students and ACT Health so that I was able to relatively quickly be called upon to assist with an outbreak investigation. Furthermore as my supervisors were supportive of my personal and professional development, I was able to supplement my outbreak investigation experience with rumour surveillance at WPRO. These opportunities are a testament to the service that MAE students are able to provide to health departments and also to the good reputation that we have internationally in the Region.
1.3 SUMMARY OF CORE ACTIVITIES RELATED TO COURSE REQUIREMENTS

Presented below are the core requirements of the MAE program and how I have satisfied these requirements.

**Investigate an acute public health problem or threat**

- Cohort study of acute gastroenteritis at a catered event (Chapter 5)
- Event-based surveillance at the World Health Organization’s Western Pacific Regional Office (Chapter 6)

**Analyse a public health dataset**

- Recent trends in syphilis in Aboriginal and Torres Strait Islander people and non-Indigenous persons in Australia; an analysis of routine surveillance data (Chapter 2)

**Evaluate a surveillance system**

- Evaluation of the Australian Sentinel Practice Research Network (ASPREN) (Chapter 3)

**Design and conduct an epidemiological study**

- Utilisation of hospital services by individuals notified with community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA), Kimberley, Western Australia (Chapter 4)

**Literature review**

- All projects (Chapters 2-6) required a critical review of the literature to develop context and scope prior to commencement. The Introduction sections of each Chapter present a summary of relevant literature as background information for the reader and also to argue the value in conducting the research. The Discussion sections of each Chapter use relevant literature to understand project results and to support recommendations or the need for further research.

**Report to a non-scientific audience**

• Weekly and bi-weekly surveillance reports for the Emerging Disease Surveillance and Response Unit (ESR), WPRO (human infection with avian influenza, dengue, hand, foot and mouth disease and seasonal influenza). These reports are available on the web and links are given to the reports I wrote in Chapter 6.

**Preparation of an advanced draft of a paper for publication in a national or international peer-reviewed journal**

• Chapter 2 is an advanced draft of manuscript that will be submitted to the Medical Journal of Australia.

**Conference presentation**

• Lunchtime lecture field report, 1 March 2016, NCEPH, Canberra. ‘Analysis of syphilis notifications at a national level 2004-2015: How are we faring?’
• 2016 Australasian Epidemiological Association 23rd Annual Scientific Meeting ‘MAE Day’ 14 September 2016, Australian National University, Canberra. ‘Does rumour surveillance work?’ (Appendix 6-1, Chapter 6)
• CDNA face-to-face meeting, 15 September 2016, DoH, Canberra. Feedback of the results of syphilis data analysis project.
• NISC teleconference, 25 October 2016, DoH, Canberra. Feedback of the results of the ASPREN evaluation.
• 2016 Australasian Sexual Health Conference, 14-16 November 2016, Adelaide. ‘Recent trends in syphilis in Aboriginal and Torres Strait Islander people and non-indigenous persons in Australia.’ (Appendix 2-1, Chapter 2)
• 8th Southeast Asia and Western Pacific Bi-regional TEPHINET Scientific Conference, 28 November-2 December 2016, Siem Reap, Cambodia. ‘Recent trends in syphilis in Aboriginal and Torres Strait Islander people and non-indigenous persons in Australia.’ (Appendix 2-1, Chapter 2)

**Teaching**

• Lessons from the field (LFF) (Chapter 7)
• Teaching exercise for MAE cohort 2016 (Chapter 7)
Coursework

- POPH8915 (Outbreak Investigation): Semester 1, 2015
- POPH8917 (Public Health Surveillance): Semester 1, 2015
- POPH8913 (Analysis of Public Health Data): Semester 2, 2015
- POPH8916 (Issues in Applied Epidemiology): Semester 1, 2016
CHAPTER 2  DATA ANALYSIS PROJECT: SYPHILIS TRENDS IN ABORIGINAL AND TORRES STRAIT ISLANDER AND NON-INDIGENOUS PERSONS IN AUSTRALIA: AN ANALYSIS OF ROUTINE SURVEILLANCE DATA

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2.1 ROLE
An epidemiological review of syphilis notifications in Australia was identified as a work item by the National Blood-borne Virus and Sexually Transmissible Infections Surveillance Sub-Committee (NBBVSTI SSC) and was raised as a project for an MAE student to undertake. Early on in the MAE, Ms Amy Bright (epidemiologist, DoH) invited me to a NBBVSTI SSC teleconference and I accepted the task as my MAE data analysis project. I performed data extraction from NNDSS, data cleaning, analysis and am first author of the manuscript. I have worked closely throughout this project with the NBBVSTI SSC and a number of members are co-authors on the manuscript. This thesis chapter is a late draft of a manuscript that will be submitted to the Medical Journal of Australia. It has been co-authored with the following people: A/Prof Rebecca Guy (Kirby Institute), Ms Carolien Giele (WA DoH), Dr Jiunn-Yih Su (NT DoH and Menzies School of Health Research), Dr Carolyn Lang (Qld DoH), A/Prof James Ward (SAHMRI), Prof Margaret Hellard (Burnet Institute), Dr Marlene Kong (Kirby Institute), Dr Skye McGregor (Kirby Institute), Dr Johanna Dups (WA DoH and ANU), Mr James Newhouse (DoH), Dr Kathryn Glass (ANU), and Ms Amy Bright (DoH). I produced all tables and figures apart from the map which was prepared by Mr James Newhouse with data that I provided.

2.2 LESSONS LEARNT
This project has been very valuable as it allowed me to take part in NBBVSTI SSC meetings as well as meetings for the Multijurisdictional Syphilis Outbreak Working Group. I have learnt through these meetings the sensitivities around reporting on sexually transmissible diseases and many of the social and cultural barriers that may challenge effective surveillance and treatment for infections such as syphilis. I have learnt the importance of defining why surveillance is conducted for an infection or a disease – why are we concerned? For syphilis I have learnt that the main public health concerns surrounding infection are the risk of congenital syphilis and the increased risk of HIV transmission that may occur concurrently with infectious syphilis. Being placed at a national level I have learned about the National BBVSTI Strategies that are in place to target public health action towards reducing the incidence of syphilis and to eliminate congenital syphilis. At a data level this project has enabled me to explore different methods of measuring disease trends over time; each with their own benefits and limitations. This issue became the topic of my LFF (Chapter 7). I am very grateful to have had the support of the NBBVSTI SCC and the opportunity to prepare this manuscript with many experts in the field of sexually transmissible infections and sexual health.

2.3 PUBLIC HEALTH IMPORTANCE
Prior to this project, the most recent available epidemiological analysis of national syphilis trends in Australia was published by James S Ward et al. in a 2011 MJA article. This analysis found that from...
2005 to 2009, notification rates for infectious syphilis substantially declined for Aboriginal and Torres Strait Islander people and significantly increased for non-Indigenous people. In 2011 an outbreak of infectious syphilis affecting Aboriginal and Torres Strait Islander people in regional and remote areas of northern Australia was officially declared. This report describes trends in infectious and congenital syphilis over a 10 year time period (2006-2015) to investigate whether similar trends were continuing for Aboriginal and Torres Strait Islander and non-Indigenous people and how the outbreak affected these trends. This project shows that post-2011, notification rates for Aboriginal and Torres Strait Islander people significantly increased with time, while for non-Indigenous people rates significantly increased across the entire study period, from 2006 to 2015. From 2006 to 2015, congenital syphilis rates were on average 30 times higher for Aboriginal and Torres Strait Islander people compared to non-Indigenous people. This epidemiological picture is at odds with the targets of the National BBVSTI Strategies which are to reduce the incidence of infectious syphilis and eliminate congenital syphilis.

As a result of this project, gaps in the collection of national surveillance data for infectious and congenital syphilis were identified. For NNDSS data, currently there is no way to link cases of congenital syphilis to the notification of his/her mother. Thus, core data collected through NNDSS for congenital syphilis notifications are limited in allowing us to understand the circumstances that may have contributed to such outcomes, particularly in relation to the provision of antenatal care in the mother. I worked on a proposal with Ms Amy Bright to modify the core NNDSS CASE_FOUND_BY field to include a category for antenatal screening. I pitched this proposal to the National Surveillance Committee (NSC). This proposal was accepted and the change was incorporated into NNDSS on October 2015.

I am currently working with Ms Amy Bright on a proposal to be presented to the NBBVSTI SSC and then to NSC which seeks to add enhanced data fields to notifications of congenital syphilis. These changes will allow us to quantify the outcomes of syphilis infection during pregnancy as well as to understand the circumstances that may have contributed to such outcomes. One proposed field will allow each congenital syphilis case to be linked to the notification of his/her mother providing the available information about the mother meets the case definition for infectious syphilis or syphilis of unspecified or > 2 years duration. Data collected in the notification of the mother (e.g. Indigenous status, age, postcode, outbreak reference, case found by (antenatal screen or other reason for testing), place of acquisition) will be useful in understanding risk factors for congenital syphilis and congenital syphilis outcomes. The second and third enhanced fields will collect information about the clinical condition associated with maternal syphilis infection including stillbirth. Although included in the case
definition, stillbirths are not specifically identified in NNDSS. This will allow an understanding of the clinical and social burden of the disease. The third enhanced field collects further information to understand risk factors for congenital syphilis outcomes (e.g. provision of antenatal care, re-infection during pregnancy). Comprehensive national surveillance data for congenital syphilis notifications would enable robust reporting against our progress towards elimination and the dissemination of this information to those responsible for public health policy and action. An initial proposal has been circulated to NBBVSTI SSC for comment. Suggestions will be incorporated, fed back to the sub-committee for final review and then submitted to NSC for their consideration.

I disseminated the results of this project to CDNA at a face to face meeting (15 September 2016) and I will give an oral presentation of this work at the Australasian Sexual Health Conference in Adelaide (14 November 2016, Appendix 2-1) and at the 8th TEPHINET Bi-Regional Scientific Conference in Cambodia (28 November-2 December 2016, Appendix 2-1). This manuscript will be submitted to the MJA for publication.

2.4 ABSTRACT

Objective: To describe time trends in syphilis notifications among Aboriginal and Torres Strait Islander people and non-Indigenous persons in Australia.

Design: A retrospective descriptive analysis of infectious and congenital syphilis notifications by Indigenous status.


Results: Among Aboriginal and Torres Strait Islander people, from 2011-2015, infectious syphilis rates increased from 29.5 to 46.8 notifications per 100,000 population and significant increasing trends occurred for both sexes, 20-29 year olds, and in very remote areas; in contrast to significant decreasing trends between 2006 and 2010. For non-Indigenous persons, in both time periods, significant increasing trends occurred for males, 20-29 and ≥40 year olds, and in major cities and outer regional areas. From 2006-2015, age-standardised rates of infectious syphilis and rates of congenital syphilis were on average six and 30 times lower, respectively, than rates for Aboriginal and Torres Strait Islander persons.
Conclusion: Infectious syphilis notifications have increased significantly in Australia over the last five years. Effective surveillance, community engagement and clinical management are required to control recent increases in syphilis transmission among Aboriginal and Torres Strait Islander persons residing in regional and remote areas and non-Indigenous males residing in metropolitan and regional centres.

2.5 INTRODUCTION
Syphilis is a sexually transmitted infection (STI) caused by the bacterium *Treponema pallidum* subspecies *pallidum* which is readily treated. Infection progresses from the initial symptomatic primary and secondary stages through to asymptomatic stages of early latent and late latent syphilis. A proportion of untreated persons will develop serious complications associated with tertiary syphilis. People with primary, secondary and early latent syphilis are infectious, while those with late latent and tertiary syphilis are not. The risk of vertical transmission from mother to child is high during the infectious stages, but is also possible during the late latent stage. Infection of the foetus can result in spontaneous abortion, stillbirth, premature delivery, perinatal death, or infection and disease in the newborn.

Syphilis is of particular public health concern among pregnant women and men who have sex with men (MSM) due to the increased risk of congenital syphilis, and human immunodeficiency virus (HIV) transmission and acquisition, respectively. Despite the existence of effective preventive measures, treatment and diagnostic assays, syphilis continues to cause significant morbidity and mortality worldwide. In Australia, syphilis transmission occurs mainly in two distinct populations: Aboriginal and Torres Strait Islander people resident in remote areas and non-Indigenous men who have sex with men (MSM) in urban areas.

From 2004, when enhanced surveillance information on infectious syphilis was first routinely collected, there has been a steady increase in the number of cases reported among MSM consistent with other developed countries. In response, the National Gay Men’s Syphilis Action Plan was developed in 2008. At around the same time, notification rates of infectious syphilis significantly declined for Aboriginal and Torres Strait Islander persons resident in remote areas, with calls for increased control efforts to achieve elimination. However, recently there has been a resurgence of infectious syphilis among Aboriginal and Torres Strait Islander people living in regional and remote regions of northern Australia with associated cases of congenital syphilis as a result of a multijurisdictional outbreak (MJSO) that began in 2011.
In this report we analyse infectious and congenital syphilis national notification data by Indigenous status over the ten year period from 2006-2015 to inform public health responses with a particular focus on trends in the five year periods pre- and post- the multijurisdictional outbreak: 2006 to 2010 and 2011 to 2015.

2.6 METHODS

2.6.1 Surveillance procedures
Infectious and congenital syphilis are nationally notifiable diseases in Australia and de-identified data on diagnoses which meet standard case definitions\textsuperscript{11,12} are provided by all jurisdictions to the National Notifiable Diseases Surveillance System (NNDSS) managed within the Australian Government Department of Health. Core notification data include information on Indigenous status, sex, age and postcode of residence at time of diagnosis. Data for confirmed cases of infectious syphilis, and confirmed and probable cases of congenital syphilis were extracted from the NNDSS using date of diagnosis for the 2006-2015 period. The date of diagnosis is the onset date or where the onset date was not known, the earliest of the following dates: specimen collection date, the notification date, or the notification received date. Due to an amendment of the case definition, probable cases of infectious syphilis have only been reported from mid-2015 and are not included in our analyses.

The Indigenous status field records if a person is of Aboriginal and/or Torres Strait Islander origin, or not (“non-Indigenous”). Notifications with unknown or missing Indigenous status were excluded from the analyses. Completeness of the Indigenous status field for infectious syphilis exceeded 50\% for each reporting jurisdiction and exceeded 90\% nationally for all years of the study. Notifications of infectious syphilis were excluded from analyses if the individual was aged less than 13 years (10 notifications).

2.6.2 Analysis
Notifications were divided into two five-year periods: 2006-2010 and 2011-2015. We first conducted a descriptive analysis of infectious and congenital syphilis notifications over the study period by Indigenous status, sex, age, jurisdiction, and remoteness determined by postcode and based on the Australian Statistical Geography Standard Remoteness Areas.\textsuperscript{13}

We calculated crude and age-standardised annual infectious syphilis notification rates per 100,000 population using the estimated mid-year resident population by Indigenous status. Age-standardised population rates by Indigenous status were calculated using the direct method, taking the 30 June 2001 population as the standard.\textsuperscript{14} Numbers of confirmed notifications associated with the ongoing MJSO
were sourced from Bright and Dups 2015.\textsuperscript{10} Congenital syphilis notification rates per 100,000 births were calculated using denominator data from the Australian Bureau of Statistics (ABS) Birth Registrations collection.\textsuperscript{15} As 2015 birth data were not available, 2014 data were used for 2015. We also calculated infectious syphilis notifications among women of childbearing age (15-49 years) due to the potential for congenital syphilis.\textsuperscript{16} We calculated notification rates by remoteness and Indigenous status using 2011 remoteness distributions provided by the ABS.\textsuperscript{17} A map was created by grouping the postcode of each notification by statistical area level 3 (SA3) regions. Notification rates were calculated using the 2011 SA3 distributions for the Australian resident population.\textsuperscript{18}

Univariate Poisson regression was used to calculate trends in infectious syphilis notification rates per 100,000 population by Indigenous status, sex, age group, remoteness, jurisdiction, and for women of childbearing age. Trends in congenital syphilis notification rates per 100,000 births were analysed by Indigenous status. The incident rate ratio interpreted as an annual trend is reported along with p-values and 95% confidence intervals (95% CI). Descriptive analyses were performed using Microsoft Excel 2010 and statistical analyses were performed using Stata version 13. P-values < 0.05 were considered statistically significant.

2.6.3 Ethics
Ethics approval was obtained from the Australian National University Human Research Ethics Committee.

2.7 RESULTS

2.7.1 Characteristics of infectious syphilis notifications
From 2006 to 2015, there were a total of 14,189 notifications of infectious syphilis of which 11,419 (80%) were reported for non-Indigenous persons, 1,946 (14%) for Aboriginal and Torres Strait Islander persons, and 824 notifications (6%) where Indigenous status was not reported. For Aboriginal and Torres Strait Islander persons over the entire study period, 1,034 (53%) notifications were among males, the median age at diagnosis was 24 years, and 1,213 (62%) notifications were reported in people residing in a remote or very remote area. For non-Indigenous persons, 10,859 (95%) notifications were among males, the median age at diagnosis was 38 years, and 10,286 (90%) notifications were reported in people residing in a major city. Figure 2-1 shows notification rates of infectious syphilis for the population of Australia by Statistical Area Level 3 (SA3) over the entire study period. The map shows high rates of infectious syphilis in remote and very remote areas of the Northern Territory and Queensland and also very high rates in metropolitan areas surrounding Melbourne, Sydney and Brisbane.
2.7.2 Characteristics of congenital syphilis notifications

From 2006 to 2015 there were a total of 52 notifications of congenital syphilis, with an average of 5 per year (range: 0-11) (Figure 2-2). Over the study period 29 cases (56%) were diagnosed in Aboriginal and Torres Strait Islander persons, 18 (35%) in non-Indigenous persons and for five notifications (10%) the Indigenous status was unknown. By jurisdiction, 18 (35%) notifications were reported from New South Wales, 18 (35%) from the Northern Territory, 13 (25%) from Queensland, and three (6%) from Western Australia. By remoteness, 20 notifications (38%) were reported from metropolitan areas, 19 (37%) from remote areas, and 12 (23%) from regional areas.
2.7.3 Trends in the Aboriginal and Torres Strait Islander population

Among Aboriginal and Torres Strait Islander people, there was a significant decreasing trend in the number of notifications and age-standardised rates of infectious syphilis from 2006 to 2010 followed by a significant increasing trend in numbers of notifications and rates from 2011 to 2015 (Table 2-1, Figure 2-3).
Table 2-1 Infectious syphilis notification trends in Aboriginal and Torres Strait Islander people, 2006-2010 and 2011-2015, by sex, age, remoteness and jurisdictions

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2010</th>
<th>Annual trend (IRR), 2006-2010</th>
<th>P</th>
<th>95% CI</th>
<th>2011</th>
<th>2015</th>
<th>Annual trend (IRR), 2011-2015</th>
<th>P</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notifications&lt;sup&gt;a&lt;/sup&gt;</td>
<td>238</td>
<td>140</td>
<td>0.85&lt;sup&gt;†&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.81-0.89</td>
<td>197</td>
<td>322</td>
<td>1.17&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>1.12-1.22</td>
</tr>
<tr>
<td>Age-standardised rate</td>
<td>41.1</td>
<td>24.4</td>
<td>0.86&lt;sup&gt;†&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.85-0.87</td>
<td>30.3</td>
<td>47.6</td>
<td>1.14&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>1.13-1.15</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
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</tr>
<tr>
<td>Males</td>
<td>40.9</td>
<td>28.7</td>
<td>0.89&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.001</td>
<td>0.84-0.95</td>
<td>33.6</td>
<td>57.4</td>
<td>1.17&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>1.10-1.24</td>
</tr>
<tr>
<td>Females</td>
<td>51.4</td>
<td>21.0</td>
<td>0.77&lt;sup&gt;†&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.72-0.83</td>
<td>34.9</td>
<td>45.0</td>
<td>1.09&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.004</td>
<td>1.03-1.17</td>
</tr>
<tr>
<td>M:F rate ratio</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Age group (yrs)</td>
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<tr>
<td>15-19</td>
<td>131.1</td>
<td>39.0</td>
<td>0.71&lt;sup&gt;†&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.64-0.78</td>
<td>108.5</td>
<td>120.7</td>
<td>1.07</td>
<td>0.10</td>
<td>0.99-1.16</td>
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<tr>
<td>20-29</td>
<td>105.4</td>
<td>58.1</td>
<td>0.82&lt;sup&gt;†&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.76-0.89</td>
<td>62.6</td>
<td>116.4</td>
<td>1.19</td>
<td>&lt;0.001</td>
<td>1.11-1.28</td>
</tr>
<tr>
<td>30-39</td>
<td>56.3</td>
<td>45.9</td>
<td>0.95&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.36</td>
<td>0.86-1.06</td>
<td>41.6</td>
<td>86.3</td>
<td>1.20</td>
<td>&lt;0.001</td>
<td>1.09-1.33</td>
</tr>
<tr>
<td>40 +</td>
<td>25.3</td>
<td>20.1</td>
<td>0.94&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.29</td>
<td>0.83-1.06</td>
<td>20.1</td>
<td>23.9</td>
<td>1.06</td>
<td>0.29</td>
<td>0.95-1.19</td>
</tr>
<tr>
<td>Women of</td>
<td>90.7</td>
<td>36.5</td>
<td>0.76&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.70-0.82</td>
<td>60.4</td>
<td>81.8</td>
<td>1.12</td>
<td>0.002</td>
<td>1.04-1.18</td>
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<td>child-bearing age&lt;sup&gt;b&lt;/sup&gt;</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Major cities</td>
<td>8.2</td>
<td>3.9</td>
<td>0.84&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.03</td>
<td>0.72-0.98</td>
<td>11.2</td>
<td>14.6</td>
<td>1.06</td>
<td>0.34</td>
<td>0.94-1.19</td>
</tr>
<tr>
<td>Inner regional</td>
<td>4.7</td>
<td>2.0</td>
<td>0.82&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.11</td>
<td>0.64-1.05</td>
<td>6.1</td>
<td>5.4</td>
<td>1.00</td>
<td>1.000</td>
<td>0.82-1.22</td>
</tr>
<tr>
<td>Outer regional</td>
<td>16.4</td>
<td>28.7</td>
<td>1.18&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.01</td>
<td>1.04-1.33</td>
<td>24.0</td>
<td>59.5</td>
<td>1.27</td>
<td>&lt;0.001</td>
<td>1.17-1.39</td>
</tr>
<tr>
<td>Remote</td>
<td>117.0</td>
<td>62.4</td>
<td>0.84&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.002</td>
<td>0.76-0.94</td>
<td>91.7</td>
<td>117.0</td>
<td>1.06</td>
<td>0.24</td>
<td>0.96-1.16</td>
</tr>
<tr>
<td>Very remote</td>
<td>139.7</td>
<td>58.9</td>
<td>0.78&lt;sup&gt;†&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.73-0.83</td>
<td>87.3</td>
<td>145.1</td>
<td>1.19</td>
<td>&lt;0.001</td>
<td>1.11-1.38</td>
</tr>
<tr>
<td>Jurisdiction&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NSW</td>
<td>5.2</td>
<td>6.1</td>
<td>1.09&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.44</td>
<td>0.88-1.34</td>
<td>3.6</td>
<td>7.6</td>
<td>1.22</td>
<td>0.03</td>
<td>1.02-1.45</td>
</tr>
<tr>
<td>NT</td>
<td>226.5</td>
<td>58.3</td>
<td>0.68&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.63-0.73</td>
<td>40.1</td>
<td>183.4</td>
<td>1.82</td>
<td>&lt;0.001</td>
<td>1.63-2.03</td>
</tr>
<tr>
<td>Qld</td>
<td>29.0</td>
<td>42.3</td>
<td>1.09&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.10</td>
<td>0.98-1.20</td>
<td>73.4</td>
<td>57.3</td>
<td>0.96</td>
<td>0.14</td>
<td>0.90-1.01</td>
</tr>
<tr>
<td>SA</td>
<td>49.9</td>
<td>6.6</td>
<td>0.57&lt;sup&gt;†&lt;/sup&gt;</td>
<td>&lt;0.001</td>
<td>0.43-0.75</td>
<td>22.6</td>
<td>29.6</td>
<td>0.94</td>
<td>0.60</td>
<td>0.75-1.18</td>
</tr>
<tr>
<td>Vic</td>
<td>23.9</td>
<td>2.7</td>
<td>0.58&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.004</td>
<td>0.40-0.84</td>
<td>13.3</td>
<td>26.5</td>
<td>1.22</td>
<td>0.11</td>
<td>0.96-1.56</td>
</tr>
<tr>
<td>WA</td>
<td>29.6</td>
<td>24.9</td>
<td>0.98&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>0.77</td>
<td>0.89-1.09</td>
<td>37.3</td>
<td>52.6</td>
<td>1.13</td>
<td>0.08</td>
<td>0.99-1.29</td>
</tr>
</tbody>
</table>

Data are presented as crude rates per 100,000 population unless otherwise indicated
95% CI, 95% Confidence Interval

IRR, Incident Rate Ratio

NSW, New South Wales; NT, Northern Territory; Qld, Queensland; SA, South Australia; Vic, Victoria; WA, Western Australia

<sup>a</sup>Excludes 3 notifications of unknown sex and 10 notifications aged less than 15 years

<sup>b</sup>Women aged 15-49 years

<sup>c</sup>Notifications for persons in the Australian Capital Territory and Tasmania excluded from analysis of rates due to low annual numbers of notifications
Notification rates for males and females followed a similar pattern; significantly decreasing from 2006 to 2010 and significantly increasing from 2011 to 2015 (Table 2-1, Figure 2-4). In 2015, rates among males and females were 57.4 and 45.0 per 100,000 population, respectively. The male-to-female rate ratio remained at 1:1 over the entire study period.
Notification rates were highest each year in the younger age groups of 15-19 and 20-29 years (except for 2009-2010) (Figure 2-5). From 2006 to 2010 there was a significant decreasing trend in notification rates for persons aged between 15-19 and 20-29 years. From 2011 to 2015, rates in persons aged 20-29 and 30-39 years significantly increased (Table 2-1). The rate of infectious syphilis in women of childbearing age significantly decreased from 2006 to 2010 but significantly increased from 2011 to 2015 (Table 2-1).
Notification rates were highest in remote and very remote areas (Table 2-1) where rates were on average 9 times higher than rates in major cities. From 2006 to 2010 notification rates significantly decreased in major cities, remote, and very remote areas and significantly increased in outer regional areas whereas from 2011 to 2015, notification rates significantly increased in outer regional and very remote areas. From 2006 to 2010, notification rates significantly decreased in the Northern Territory, South Australia, and Victoria while from 2011 to 2015, rates significantly increased in the Northern Territory and New South Wales. No significant trend from 2011 to 2015 occurred for South Australia, Victoria, Queensland and Western Australia. The largest annual rate increase from 2011 to 2015 occurred in the Northern Territory (increase of 82%, 95% CI 63%, 103%) (Table 2-1). Figure 2-6 shows national and jurisdictional notifications for 2006 to 2010 and 2011 to 2015 for Aboriginal and Torres Strait Islander persons. For the 2011 to 2015 period, the contribution of confirmed cases associated with the ongoing MJSO\textsuperscript{16} to the total number of notifications for Queensland, the Northern Territory, Western Australia, and nationally are shown. For Aboriginal and Torres Strait Islander people, cases attributable to the multijurisdictional outbreak accounted for 74%, 73%, 25% and 60% of the total number of notifications over the 2011 to 2015 period for Queensland, the Northern Territory, Western Australia, and nationally, respectively.
On average, annual rates of congenital syphilis were 30 times higher than for the non-Indigenous population. For example, in 2015, rates of congenital syphilis for Aboriginal and Torres Strait Islander people and non-Indigenous persons were 11.2 and 0.4 per 100,000 live births, respectively.

2.7.4 Trends in the non-Indigenous population

For non-Indigenous persons, the number of notifications and age-standardised rates of infectious syphilis significantly increased across both time periods (Table 2-2, Figure 2-3). For males, notification rates significantly increased across both time periods and there was no significant trend among females. The male-to-female rate ratio increased across the study period from 10:1 in 2006 to 32:1 in 2015 (Table 2-2). Rates were highest in the 30 to 39 year age group (Figure 2-5). From 2011 to 2015, notification rates significantly increased for all age groups except those aged 15 to 19 years.
(Table 2-2). There was no significant trend in the rate of infectious syphilis in women of childbearing age across either time period (Table 2-2).

Table 2-2 Infectious syphilis notification trends in non-Indigenous people, 2006-2010 and 2011-2015, by sex, age, remoteness and jurisdictions

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>2006</th>
<th>2010</th>
<th>Annual trend (IRR), 2006-2010</th>
<th>P</th>
<th>95% CI</th>
<th>2011</th>
<th>2015</th>
<th>Annual trend (IRR), 2011-2015</th>
<th>P</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notificationsa</td>
<td>569</td>
<td>889</td>
<td>1.07† &lt;0.001</td>
<td>1.05-1.09</td>
<td>1,001</td>
<td>1,674</td>
<td>1.13‡ &lt;0.001</td>
<td>1.11-1.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-standardised rate</td>
<td>2.9</td>
<td>4.2</td>
<td>1.06 † &lt;0.001</td>
<td>1.03-1.08</td>
<td>4.7</td>
<td>7.4</td>
<td>1.12‡ &lt;0.001</td>
<td>1.10-1.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>5.1</td>
<td>7.8</td>
<td>1.12‡ &lt;0.001</td>
<td>1.04-1.08</td>
<td>8.7</td>
<td>14.1</td>
<td>1.12‡ &lt;0.001</td>
<td>1.10-1.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0.5</td>
<td>0.5</td>
<td>0.99 0.77</td>
<td>0.91-1.07</td>
<td>0.5</td>
<td>0.5</td>
<td>0.94 0.19</td>
<td>0.87-1.03</td>
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</tr>
<tr>
<td>M:F rate ratio</td>
<td>10</td>
<td>16</td>
<td>- -</td>
<td>-</td>
<td>18</td>
<td>32</td>
<td>- -</td>
<td>-</td>
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<tr>
<td>Age group (yrs)</td>
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<td></td>
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</tr>
<tr>
<td>15-19</td>
<td>1.3</td>
<td>1.4</td>
<td>1.07 0.34</td>
<td>0.93-1.24</td>
<td>1.7</td>
<td>1.6</td>
<td>1.00 0.95</td>
<td>0.88-1.13</td>
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<td></td>
</tr>
<tr>
<td>20-29</td>
<td>3.9</td>
<td>7.0</td>
<td>1.12† &lt;0.001</td>
<td>1.07-1.17</td>
<td>7.9</td>
<td>15.0</td>
<td>1.18‡ &lt;0.001</td>
<td>1.14-1.22</td>
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</tr>
<tr>
<td>30-39</td>
<td>6.7</td>
<td>8.3</td>
<td>1.01 0.56</td>
<td>0.97-1.05</td>
<td>9.1</td>
<td>14.3</td>
<td>1.12‡ &lt;0.001</td>
<td>1.08-1.16</td>
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</tr>
<tr>
<td>40+</td>
<td>2.6</td>
<td>4.0</td>
<td>1.05 † 0.002</td>
<td>1.02-1.08</td>
<td>4.5</td>
<td>6.5</td>
<td>1.08‡ &lt;0.001</td>
<td>1.06-1.11</td>
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<tr>
<td>Women of child-bearing ageb</td>
<td>0.9</td>
<td>0.9</td>
<td>1.02 0.63</td>
<td>0.93-1.12</td>
<td>0.9</td>
<td>0.8</td>
<td>0.95 0.24</td>
<td>0.87-1.04</td>
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<tr>
<td>Remotenessc</td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Major cities</td>
<td>3.4</td>
<td>5.1</td>
<td>1.14 † &lt;0.001</td>
<td>1.04-1.08</td>
<td>5.9</td>
<td>9.7</td>
<td>1.13‡ &lt;0.001</td>
<td>1.11-1.15</td>
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<tr>
<td>Inner regional</td>
<td>0.9</td>
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Data are presented as crude rates per 100,000 population unless otherwise indicated

IRR, Incident Rate Ratio
95% CI, 95% Confidence Interval

†p<0.05

*aExcludes 10 notifications of unknown sex and 1 notification of nonsensical age
bWomen aged 15-49 years

Notification rates were highest in major cities (Table 2-2) with rates significantly increasing across both study periods in major cities and outer regional areas. From 2011 to 2015 rates significantly
increased in inner regional areas. By jurisdiction, between 2006 and 2010, there was no significant trend in rates except for the Australian Capital Territory, New South Wales and Victoria where rates significantly increased. From 2011 to 2015, rates significantly increased in New South Wales, the Northern Territory, Queensland, South Australia, and Victoria. The largest annual rate increase from 2011 to 2015 occurred in the Northern Territory (increase of 80%, 95% CI 40%, 131%) (Table 2-2).

2.8 DISCUSSION

Over the last decade, Australia has experienced sustained increases in infectious syphilis notifications, as in a number of developed countries. The epidemics in MSM in the major cities of Australia are well characterised and are reflected in the increasing male-to-female rate ratios observed in our analyses for non-Indigenous persons, particularly over the last five years. For non-Indigenous persons, the second half of the study period saw significantly increased rates of infectious syphilis across a wide range of ages and geographical areas. Substantial disparities in syphilis rates between Aboriginal and Torres Strait Islander people and non-Indigenous persons are evident from our analyses. The Aboriginal and Torres Strait Islander population of Australia comprise 3% of the total Australian population but 14% of all infectious syphilis notifications in the study period.

There are a few limitations to consider when interpreting these data. The use of national notifications restrict the study population to people who have been tested and diagnosed with infectious syphilis and may under-estimate the true burden of infection in the population. Also any changes in testing policies and programs, diagnostic assays, awareness campaigns and other factors that may influence health-seeking behaviour may affect trends in notifications. Our analysis excluded notifications where the Indigenous status was unknown or missing to avoid making assumptions of the true status. The profile of these excluded notifications indicated that these people were mostly non-Indigenous (majority male, resided in major cities, median age of 38 years), thus underestimating notification rates of infectious syphilis in non-Indigenous people in this study. Lastly, until mid-2015, the national case definition for infectious syphilis led to many potential cases, particularly 15-19 year olds, being excluded due to lack of past testing information to confirm incident infection in the last two years. Effective since mid-2015, the addition of a probable case definition allows for the reporting of persons with no known previous reactive serology but who meet other specified criteria. Probable cases were not included in this study.

Our analysis showed that for the first half of the study period (2006 to 2010) significant reductions in the rates of infectious syphilis were observed for Aboriginal and Torres Strait Islander people of both sexes, for the youngest age groups, and in the majority of geographical areas. The second half of the
study period (2011 to 2015) coincided with an ongoing outbreak of syphilis affecting Aboriginal and Torres Strait Islander people living in remote and regional areas of northern Australia.\textsuperscript{10} Comparing 2011 to 2015, crude rates of infectious syphilis in Aboriginal and Torres Strait Islander people increased for both sexes, for all age groups, and in the majority of regions and jurisdictions. We showed that for Aboriginal and Torres Strait Islander people over the 2011 to 2015 period, cases associated with the outbreak accounted for over half the total number of cases for Queensland, the Northern Territory and nationally. It is likely that a combination of increased syphilis transmission and active case finding during the outbreak contributed to this increase. However not all changes can be attributed to the outbreak, as rates also increased in jurisdictions unaffected by the outbreak including New South Wales and Victoria. From 2011 to 2015, in New South Wales the male to female rate ratio of infectious syphilis among Aboriginal and Torres Strait Islander people increased from 1:1 to 13:1 and in Victoria the rate ratio remained stable at 4:1, implying predominantly male to male transmission in these jurisdictions.

Over the last five years there has been no significant decrease in the rate of congenital syphilis for Aboriginal and Torres Strait Islander people and non-Indigenous persons. In 2015, the rate of congenital syphilis in Aboriginal and Torres Strait Islander people was 32 times higher than the rate in non-Indigenous populations. Additionally, a significant increase in the rate of infectious syphilis in Aboriginal and Torres Strait Islander women of childbearing age over the last five years indicates an increased risk of congenital syphilis in the future. For Aboriginal and Torres Strait Islander people, the majority of congenital syphilis cases over the last 10 years were reported from remote areas where healthcare is relatively inaccessible.\textsuperscript{21} To prevent future cases, we need to identify the gaps and inconsistencies in access to antenatal care, and antenatal detection and treatment to strengthen health systems. National clinical guidelines recommend syphilis testing at the first antenatal visit,\textsuperscript{22} yet there are no national data available on the uptake of syphilis screening in pregnancy.

The current outbreak of syphilis affecting Aboriginal and Torres Strait Islander people in regional and remote areas of Australia is exacerbated by the mobility of young people in remote areas and a multi-jurisdictional response is vital. In 2015, a Multijurisdictional Syphilis Outbreak Group of the Communicable Diseases Network Australia (CDNA) was formed with a focus on supporting a coordinated response to the outbreak, including enhanced STI diagnosis, treatment and control programs, and also the provision of enhanced data to further understand the epidemiology.\textsuperscript{10} It is important to note that in remote areas, health service delivery is primarily the responsibility of primary health services where there are multiple competing priorities and a high turn-over of staff. Any response to controlling STIs in remote areas cannot overlook the need for further resourcing and
support for these services and also public health programs. In regards to the steady increase in syphilis observed in non-Indigenous males, mostly due to male-to male sex, new innovative programs may be required to control the infection, such as chemoprophylaxis.\textsuperscript{23} Although there has been increased testing in MSM in the past five years, including opt-out and opt-in initiatives at clinical services,\textsuperscript{24} this has been insufficient to combat the rising rates of syphilis in this population.

The elimination of syphilis transmission and congenital syphilis cases are identified priorities on a global and national scale.\textsuperscript{25-26} It was once said that “drugs alone do not stop venereal disease.”\textsuperscript{27} This is particularly true for syphilis; a disease that requires a comprehensive approach beyond therapeutic management for its control. Such an approach should involve health promotion and strengthening health services in areas of most need. Despite the increasing trends observed in this study for Aboriginal and Torres Strait Islander persons and non-Indigenous people, particularly over the last five years, it is important that the elimination of syphilis remains a national priority. The coordinating work of the MJSO Group is targeted towards ending the current outbreak.\textsuperscript{10} This presents a timely opportunity to capitalise on the momentum generated by the current syphilis outbreak response and focus resources and efforts towards elimination.

2.9 REFERENCES


2.10 APPENDICES

Appendix 2-1 Conference presentation at Australasian Sexual Health Conference (14 November 2016, Adelaide) and the 8th TEPHINET Bi-Regional Scientific Conference (28 November to 2 December 2016, Siem Reap, Cambodia)

**Recent trends in syphilis in Aboriginal and Torres Strait Islander and non-Indigenous persons in Australia:**
An analysis of routine surveillance data

*Dr Amy Burroughs*
MAE Scholar, 2015-2016
Field placement: Australian Government Department of Health
Supervisors: Kathryn Glass, Maryn Kirk, Cindy Toms and Jennie Hood
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**Disclosure statement**

- No conflicts of interest to declare
Outline

1. National syphilis surveillance
2. Syphilis epidemiology
3. Analysis of national syphilis notifications
4. Gaps in national data collection

Syphilis surveillance in Australia

- Local
- State/Territory
- National
  - Detect outbreaks
  - Identify national trends
  - Provide guidance for policy development
  - Meet various international reporting requirements
National syphilis surveillance

- National Notifiable Diseases Surveillance System (NNDSS)
- De-identified data provided by states/territories
- 3 categories
- Case definitions
- Core and enhanced data
- Underestimate

Aboriginal and Torres Strait Islander people

- First inhabitants of Australia
- Comprise diverse Aboriginal nations
  - Own language
  - Own traditions
  - Historically lived on mainland Australia, Tasmania or on many of the continent’s offshore islands
- Torres Strait Islander peoples come from the islands of the Torres Strait
  - Melanesian origin
  - Distinct identity, history and cultural traditions
- Many Torres Strait Islanders live on mainland Australia


Syphilis epidemiology in Australia

- Number of notifications highest for non-Indigenous persons
- Rates highest for Aboriginal and Torres Strait Islander people
- Current outbreak of infectious syphilis
- National BBVSTI Strategies
Study objectives

1. Identify trends in syphilis notifications
   - 2006-2010 and 2011-2015
   - Aboriginal and Torres Strait Islander people and non-Indigenous people
2. Examine the influence of current outbreak
3. Identify gaps in collection of national surveillance data

Methods

- Data extracted NNDSS
- Infectious and congenital syphilis
- Age-standardised and crude rates
- Poisson regression
- Exclusions
  - Missing Indigenous status,
  - Probable infectious syphilis notifications
  - Persons under 13 years
Summary of Results

- Despite declining trends in the notification rate of infectious syphilis in Aboriginal and Torres Strait Islander persons prior to 2010, there has been a significant increase over the past five years.

- A substantial fraction of this increase is due to a syphilis outbreak in remote Northern Australia.

- Increases in infectious syphilis notification rates continued in non-indigenous males.

- Cases of congenital syphilis continue.

Gaps in surveillance

- Testing denominator
- Re-infection/co-infection
- Understanding congenital syphilis cases
  - Currently cannot link congenital syphilis case with his/her mother
  - Miss important contextual information
- Sexual exposure
  - Infer same sex practice from M:F
- Working with NBBVSTI SSC improve
Acknowledgements (1/2)

NBBVSTI SSC:
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- Ms Carolien Giele (WA DoH)
- Dr Jiumn-Yin Su (NT DoH/Menzies School of Health Research)
- Dr Carolyn Lang (Qld DoH)
- A/Prof James Ward (SAHMR)
- Prof Margaret Hellard (Burnet Institute)

- Dr Marlene Kong (Kirby Institute)
- Dr Skye McGregor (Kirby Institute)
- Dr Johanna Dups (WA DoH/ANU)
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- Dr Kathryn Glass (ANU)
- Ms Amy Bright (DoH)

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DoH: Amy Bright, Oriana Wallace, Rhonda Owen, Cindy Toms, Jennie Hood, Mark Trungrove, Rachael Corvisy
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3.1 ROLE
The need for an updated evaluation of the Australian Sentinel Practice Research Network (ASPREN) was identified by the National Influenza Surveillance Committee (NISC), a sub-committee of the Communicable Diseases Network Australia (CDNA). I was the lead investigator and author in this evaluation. I worked with influenza epidemiologists and the Director of the Vaccine Preventable Diseases Surveillance Section at the Department of Health to list the national objectives of ASPREN and to identify key stakeholders of the system. Prior to this evaluation, the national objectives for the system were described in contract agreements but had not been clearly defined and listed in one place. I visited ASPREN administration and spent a week understanding the system and collecting relevant data for the evaluation. I formulated, developed, and administered the surveys used to collect stakeholder views of the system and extracted, cleaned, and analysed relevant influenza surveillance data from ASPREN and the National Notifiable Diseases Surveillance System (NNDSS). Christina Bareja, an influenza epidemiologist at the Department assisted with the extraction of ASPREN data. Once finalised, this evaluation was shared with ASPREN administration and general recommendations were presented to the National Influenza Surveillance Committee (NISC).

3.2 LESSONS LEARNT
At the beginning of this project I thought it was my job to both identify where the system needs improvement AND to fix these issues. However, I have learnt that the role of an evaluator is to clearly highlight where deficiencies are and what may be considered for system improvement rather than to solve the shortcomings. I have learnt that the most relevant recommendations are usually the most obvious and not to think too deeply about improvements as complex recommendations may not be the most practicable. For influenza specifically I have a new respect for the complexity of its epidemiology and the need for multiple sources of surveillance data gain an understanding of transmission and clinical severity. In Australia no one influenza surveillance system can tell the whole story and this is the same situation internationally. Most importantly I have learnt that the usefulness of a surveillance system really depends on having clear system objectives and agreed public health actions taken for defined surveillance signals.

3.3 PUBLIC HEALTH IMPLICATIONS
Outcomes of this evaluation have provided the Department of Health with an assessment of the utility of sentinel GP surveillance for influenza and recommendations as to how to improve system efficiency. I believe this evaluation has prompted the Department of Health to re-evaluate system objectives in order to obtain data that are useful and used. More broadly I hope this evaluation sparks a discussion of how to standardise the interpretation of influenza data across surveillance systems, as well as to
trigger an investigation into alternative and epidemiologically meaningful measures of representation. At the request of NISC members, the ASPREN evaluation will be distributed to the committee and also to other interested stakeholders.

3.4 ABSTRACT

Objective: To evaluate the Australian Sentinel Practice Research Network (ASPREN) against the objectives set for the system by the funding body, the Australian Government Department of Health.

Importance of study: Syndromic surveillance for influenza-like illness (ILI) is an important component of national influenza surveillance as it acts as an indicator of influenza virus transmission activity and clinical severity of disease in the community. The results of this evaluation inform recommendations to improve the quality of data on which public health decisions are made.

Methods: The Centres for Disease Control and Prevention (CDC) guidelines for evaluating public health surveillance systems were used to assess the usefulness of the current system and nine system attributes. Responses to annual general satisfaction surveys were collected by ASPREN administrators and were used to assess the acceptability of the system to general practitioners (GPs). Stakeholders were identified (N=14) and included representatives from the Commonwealth, state and territory epidemiologists, representatives from SPNWA, VicSPIN, the World Health Organization Collaborating Centre for Reference and Research on Influenza (WHO CC), and OzFoodNet. Stakeholders were surveyed to understand how they use ASPREN data and their perceptions of system performance. ASPREN syndromic and virological data for 2011-2015 were analysed to assess timeliness, representativeness, predictive value positive, sensitivity, and data quality.

Results: The data collected through ASPREN are recognised by stakeholders as complementing and filling gaps in national influenza surveillance; principally as an early indicator of influenza transmission and clinical severity in the community, a source of data to ‘ground’ laboratory-confirmed notifications of influenza, and a valuable source of relatively un-biased specimens for influenza virological characterisation. ASPREN syndromic data were found to be timely and with a good predictive value for influenza infection. However, due to poor system performance in representation, simplicity, and sensitivity, there is a lack of confidence in the signals generated by short-term changes in ASPREN syndromic data.

Conclusion: Recommendations are made to improve the representativeness, simplicity, sensitivity, and usefulness of ASPREN syndromic and virological data. Defining evidence-based targets for
representativeness of primary care ILI surveillance systems is challenging but necessary for the collection of meaningful data.

3.5 INTRODUCTION

3.5.1 The public health importance of influenza in Australia

Influenza, or “flu”, is a disease caused by infection with influenza virus.\(^1\,^2\) In temperate climates, annual epidemics of influenza occur during the winter months.\(^2\) Influenza viruses are classified into types A, B, and C.\(^1\) Influenza virus types A and B are clinically important and can be further divided into different virus subtypes and strains.\(^1\) In Australia, predictions are made as to the likely strains that will circulate during seasonal epidemics. These predictions are based on information from previous seasons as well as current epidemics occurring in the northern hemisphere.\(^2\) Based on recommendations of the World Health Organization (WHO), seasonal influenza vaccinations are formulated and are available prior to the influenza season each year in Australia.\(^2\)

Influenza A viruses have a segmented genome, giving the opportunity for ‘genetic shift’ whereby genetic material is exchanged between different virus strains creating novel strains. If such a novel strain is capable of person-to-person transmission, influenza virus pandemics may arise where the protective immunity of the population is minimal and increased morbidity and mortality rates occur.\(^1\) The most recent example of such a pandemic was the global circulation of a novel influenza virus subtype H1N1 which was first detected in Australia in 2009.\(^1\)

Influenza is a common disease. In 2015 there were 100,558 laboratory confirmed cases of influenza in Australia which gave a crude national annual notification rate of 420 cases per 100,000 population.\(^3\) It is important to note that notification counts are an underestimate of the true influenza burden in the community, and do not capture those cases which do not present to health care, or present to healthcare but do not receive laboratory confirmation of infection.\(^4\) Commonly quoted community attack rates for seasonal influenza in Australia vary between 5% and 20% but may be as low as 1% in years of low activity.\(^5\)

Infection with influenza virus may result in no apparent (asymptomatic) symptoms or disease of severe morbidity and mortality.\(^6\) The severity of disease depends upon the virulence of the strain, the degree of protective immunity in the individual and the population, as well as the presence of co-morbidities in the individual. Although most healthy children and adults have minor symptoms, certain subsets of the population are known to have higher morbidity and mortality rates associated with influenza. Those individuals at a higher risk of severe outcomes include the elderly (> 60 years of age), the very young
(< 5 years of age), pregnant women, and those of any age who have existing health problems such as heart, lung, kidney, liver, immune, or metabolic disease. Mathematical modelling suggests there are on average 13,500 hospitalisations and over 3,000 deaths per year in Australians aged 50 years and over. The case fatality rate for seasonal influenza may vary between 0.14% and 1.4% given different estimates of attack rates. During pandemics, severe disease may occur irrespective of age and general health status.

Influenza is a costly disease. Using the costs associated with the use of healthcare services: general practitioner consultations and hospital admissions, it has been estimated that the annual cost to the Australian health care system due to influenza is $115 million. Higher financial burden may be felt during pandemic situations. For example, during the 2009 H1N1 pandemic, the virus was capable of causing severe disease, especially in the young to middle aged, and the impact on intensive-care units (ICUs) was higher compared to seasonal flu. One study found that the total cost of treating patients in Australian and New Zealand ICUs during the winter of the pandemic was more than $65 million. These estimated costs do not consider the financial losses associated with absenteeism from the workforce. In 2008, 1.5% of employees were absent from work for more than three consecutive days due to influenza. During the 2009 pandemic, 57% of surveyed emergency nursing and medicine staff who became ill reported absenteeism of at least one day with an average time off work of 3.7 days, resulting in loss to the essential provision of health care.

3.5.2 Influenza surveillance in Australia

According to the National Influenza Surveillance Scheme, the national objectives of influenza surveillance in Australia are to:

1. Ensure the early detection of influenza epidemics;
2. Trigger public health prevention and control activities;
3. Characterise the epidemic, especially identification of risk groups and disease severity;
4. Estimate the impact of the epidemic;
5. Characterise the circulating viruses to inform vaccine virus selection and assess the effectiveness of antiviral medications; and
6. Ensure flexibility to enable adaptability for responding to additional surveillance requirements during a pandemic or particularly severe season.

Due to the wide clinical spectrum of influenza virus infections, surveillance of influenza in Australia uses a range of sources to detect infection at differing levels of disease severity in order to understand disease epidemiology and ultimately to inform public health responses (Figure 3-1).
3.5.2.1 Laboratory surveillance for influenza in Australia

The primary and most standardised system for influenza surveillance in Australia is the National Notifiable Diseases Surveillance System (NNDSS). A national case definition is used for the reporting of laboratory-confirmed influenza infections. NNDSS notifications consist of patients presenting to primary care, emergency departments, or to hospital. For notifications of laboratory confirmed influenza, a field is available for all states and jurisdictions to record the mortality status of the case, where case follow up or linkage with morbidity collections has been undertaken. The completeness and timeliness of this field is poor and likely underestimates the true number of mortalities associated with influenza virus infection. Currently there are no denominator data for NNDSS notifications; the magnitude of which are influenced by the amount of testing.

Laboratory-based surveillance is also conducted by National Influenza Centres (NICs) which are part of the World Health Organization (WHO) Global Influenza Surveillance and Response System. There are three NICs in Australia: PathWest Laboratory Medicine in Perth, the Institute of Clinical Pathology...
and Medical Research (ICPMR) in Sydney, and Victorian Infectious Diseases Reference Laboratory (VIDRL) in Melbourne. NICs report both numerator and denominator data for influenza virus testing. The WHO Collaborating Centre for Reference and Research on Influenza (WHO CC) in Melbourne receives influenza virus samples from laboratories around Australia for virus identification and advanced antigenic and genetic analysis to monitor virus evolution and sensitivity to antiviral drugs.

3.5.2.2 Sentinel surveillance at primary care centres in Australia

Using data collected from 2000 to 2006, each year it is estimated that on average, influenza infection is associated with over 300,000 general practitioner (GP) consultations. Surveillance of influenza-associated GP consultations in Australia is achieved through monitoring a syndrome: influenza-like illness (ILI), using sentinel GP practitioners/practices. Surveillance of ILI by GPs is designed to capture persons with a defined set of signs and symptoms that require primary medical care. The national sentinel GP ILI surveillance system is the Australian Sentinel Practice Research Network (ASPREN) which has sentinel GPs in 7 of 8 states and territories (all except Western Australia). Western Australia administers its own sentinel practice network (SPNWA), as does Victoria (VicSPIN) for monitoring local influenza activity. ASPREN, SPNWA, and VicSPIN all include a laboratory testing component where ILI patients are selected for swab collection and respiratory pathogen analysis. The similarities and differences between ASPREN, SPNWA, and VicSPIN are shown in Table 3-1.
Table 3-1. Comparison of key attributes of sentinel GP syndromic influenza surveillance systems in Australia (ASPREN, SPNWA, and VicSPIN)

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<td>Acute upper respiratory tract infection characterised by fever, cough, and fatigue</td>
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<tr>
<td></td>
<td>1 GP/50,000 people in rural and remote areas</td>
<td>1 GP/50,000 people in rural and remote areas</td>
<td></td>
</tr>
<tr>
<td><strong>Reporting methods</strong></td>
<td>ASPREN MIS (web)</td>
<td>ASPREN MIS (web)</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>Canning Flu Tool</td>
<td>Canning Flu Tool</td>
<td>Email</td>
</tr>
<tr>
<td></td>
<td>Paper</td>
<td>Paper</td>
<td>Fax</td>
</tr>
<tr>
<td><strong>Period of operation</strong></td>
<td>Year-round</td>
<td>Year-round</td>
<td>Flu season only</td>
</tr>
<tr>
<td><strong>Target % ILI swabbed</strong></td>
<td>20%</td>
<td>No-target</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Method of ILI swabbed patient selection</strong></td>
<td>Systematic</td>
<td>GP discretion</td>
<td>GP discretion</td>
</tr>
</tbody>
</table>

Syndromic and virological data from SPNWA and syndromic data from VicSPIN are combined with ASPREN data however system differences make interpretation difficult and may require weighting calculations.

3.5.3 The Australian Sentinel Practice Research Network (ASPREN)

ASPREN was established in 1991 by the Royal Australian College of General Practitioners (RACGP) as a network of sentinel general practitioners, and since 2014 nurse practitioners, who collect information on selected diseases and/or syndromes with the information reported at a national level. Currently the number of nurse practitioner reporters is low and thus throughout this evaluation, reporters will be considered GPs. The project is funded by the Australian Government Department of Health (the Commonwealth) and directed through the Discipline of General Practice at the University of Adelaide. Through surveillance for ILI, ASPREN contributes to national influenza surveillance objectives 3-6 (page 41). The objectives for ASPREN, as stipulated by the Commonwealth, are:
1. To provide a flexible system for the collection of nationally representative data on disease syndromes in the community

2. To act as a nationally representative indicator of influenza activity (through ILI surveillance) in the community in real-time

3. Through systematic and representative sampling and testing of ILI patients, quantitatively determine the predictive value of ILI for influenza activity

3.5.3.1 Operation of ASPREN

Participation in the program by primary health care providers is voluntary and is rewarded with significant continuing professional development points (CPD) and monetary benefits depending on the level of membership. Recruitment of GPs occurs year round with the major round conducted prior to the beginning of the influenza season each year. As per the contract for services, ASPREN administration are required to achieve and maintain a geographically and population based representative number of general practices at both the national level and at the metropolitan, rural, and remote levels. Geographical remoteness may be defined as per the Australian Government Department of Health’s Rural, Remote and Metropolitan Areas (RRMA) classification system or an equivalent classification system. Representation is set at a ratio of one primary health care provider per 200,000 population in metropolitan areas and one primary health care provider per 50,000 population in rural and remote areas. Where there is more than one GP from a single practice, ASPREN administration must ensure that this does not impact upon representativeness. The target number of GPs per population by remoteness is consistent with the recommendations of Australia’s Influenza Pandemic Plan. A wide range of methods are used to facilitate recruitment including the use of social media and incentives are given to GPs who refer other colleagues in under-represented areas.

General practitioners may sign up as Silver, Gold or Platinum members with reporting requirements and associated benefits shown in Table 3-2.
<table>
<thead>
<tr>
<th>Reporting requirements</th>
<th>Silver</th>
<th>Gold</th>
<th>Platinum</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Syndromic surveillance ILI</td>
<td>• Syndromic surveillance ILI + other conditions</td>
<td>• Syndromic surveillance ILI + other conditions</td>
<td></td>
</tr>
<tr>
<td>• Consultation totals</td>
<td>• Consultation totals</td>
<td>• Virological surveillance (swab testing)</td>
<td>• Consultation totals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Silver</th>
<th>Gold</th>
<th>Platinum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 category 2 ACRRM or RACGP QI&amp;CPD points per annum</td>
<td>10 category 2 ACRRM or RACGP QI&amp;CPD points per annum</td>
<td>40 category 1 ACRRM or RACGP QI&amp;CPD points per triennium and 10 category 2 points per annum</td>
<td></td>
</tr>
<tr>
<td>$25 per swab taken, up to a maximum of $1,000 per year</td>
<td>$25 per swab taken, up to a maximum of $1,000 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Priority notification of results. GPs who send their samples will receive results within 24 hours of receipt of the sample by SA Pathology</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ASPREN system started collecting syndromic data from 1991. From 1991-2006 data were collected and stored in spreadsheets maintained on University of Adelaide servers. These data are generally considered by ASPREN administrators to be difficult to interpret due to a lack of data dictionaries. In 2006 the ASPREN Management System (MIS) web reporting page was established whereby GPs manually log on and record details of each patient that meets the syndromic case definition(s). In 2007, ASPREN administration employed the services of Adelaide University’s Data Management and Analysis Centre (DMAC) which maintains a database to collate and to a certain extent quality control syndromic data. With DMAC on board, data usability improved. In November 2010, ASPREN administration employed the services of a single contractor for the use of an automated data extraction tool. The tool is the Canning Flu Tool and is compatible with Best Practice, Medical Director, Zed Med, PractiX or MedTech practice software. The Canning Flu Tool does require new versions and updates. An overall ASPREN system rebuild including a Canning Flu Tool and DMAC upgrade is currently in development. The last method of reporting syndromic data is via manual paper templates that are mailed, faxed or emailed to ASPREN administration. DMAC collates data that are
reported via Canning Flu Tool or via the MIS interface. New recruits can choose either one of the three reporting options at sign-up or may change reporting method throughout their membership.

Syndromic surveillance of ILI has been consistently reported since 1991. Gold and Platinum GPs are currently reporting on three other diseases: gastroenteritis, chickenpox and shingles. From 2013 Platinum GPs could also elect to report on presentations of pertussis, upgrading their membership to Platinum Plus status to gain extra CPD points. The list of reportable conditions is reviewed annually by the ASPREN management committee. For ILI the case definition is a patient experiencing fever, cough and fatigue. The denominator used for rates of ILI (and other conditions) is the number of weekly consultations per GP. If using the web-based or paper-based reporting method, at the end of each week, consultation totals are entered by the GP, practice staff or ASPREN administration. For the Canning Flu Tool, consultation numbers are automatically extracted if the practice has Pracsoft or Best Practice Billing, or the Tool will calculate the number of patient records that have been opened for more than three minutes within the week.

In response to the H1N1(2009) pandemic, laboratory testing of ILI cases was implemented in 2010 and is performed by Platinum GP members. GPs are asked to take nasal swabs of 20% of the ILI patients that they see during a week. Selection of this 20% should be systematic but also practical. Examples of systematic approaches recommended to GPs by ASPREN administration include the swabbing all ILI patients on a particular day each week or selecting patients with a surname beginning A-E. Swab testing kits are sent out to GPs before the beginning of the flu season. Prior to 2015, ASPREN swabs were sent to SA Pathology and tested for a panel of respiratory pathogens: influenza A (type and H1 pdm09 subtype), influenza B, respiratory syncytial virus, parainfluenza viruses 1-3, adenovirus, enterovirus, human metapneumovirus, *Mycoplasma pneumonia*, and pertussis. Influenza-positive specimens with high viral loads (CT≤30) were retained and forwarded in batches to the WHO CC in Melbourne for subtyping and further virological analyses including antiviral resistance testing. From 2015, influenza typing will be performed by the WHO CC.

Figure 3-2 shows the timing and process of data flow through the ASPREN system as well as how SPNWA and VicSPIN data are integrated. For ASPREN and SPNWA GPs who use the Canning Flu Tool, syndromic data are downloaded into the DMAC database weekly on a Sunday/Monday. For ASPREN and SPNWA GPs who use web-reporting, syndromic data are entered in real time through the MIS interface and enter the DMAC database. Consultation numbers are downloaded or entered weekly. For those GPs who use paper-based reporting, these are sent weekly to ASPREN administrators who manually enter these data into the DMAC database via the MIS interface. ASPREN
administration, enrolled GPs, and jurisdictional and Commonwealth health representatives can access these data at any time via the MIS interface. VicSPIN syndromic data are emailed fortnightly in a spreadsheet to ASPREN administration with these data being incorporated into the fortnightly report; however these data are not integrated into the weekly Commonwealth report. Instead, aggregate VicSPIN syndromic data are sent in a separate file directly to the Commonwealth.

**Figure 3-2. Syndromic data flow through ASPREN system**

Figure 3-3 shows the timing and flow of samples and data for ASPREN virological surveillance, including how data from SPNWA are incorporated. For samples collected through ASPREN and SPNWA, results of influenza and other respiratory pathogen panel testing are emailed weekly in spreadsheets to ASPREN administration. Analyses performed at the WHO CC are more complicated and less timely. Results from the WHO CC are received by ASPREN administration when results are available.
ASPREN administration is required to report ILI syndromic and all virological data once a week to the Commonwealth. The Commonwealth use ASPREN data for the Department’s fortnightly Australian Influenza Surveillance Report (http://www.health.gov.au/flureport) and other influenza activity updates. ASPREN administration, through the National Influenza Surveillance Committee (NISC), a sub-committee of the Communicable Diseases Network Australia, also provides regular updates of its data collection and data analyses. Every fortnight ASPREN administration distributes a report to members and subscribers detailing the results of surveillance for ILI and other conditions.

3.5.3.2 Resources required to operate ASPREN

The Department has provided funding to ASPREN since 2007. The current contract for the surveillance of ILI through sentinel general practices covers the 2015 and 2016 calendar years. This contract includes a Deed of Variation to fund additional testing due to high levels of influenza activity in the 2015 season. ASPREN receives no additional external funding. Currently ASPREN administration comprises three part time employees. The provision of data from SPNWA and VicSPIN to ASPREN administration is in-kind and relies on a positive working relationship between the administrators of the systems.
3.6 MATERIALS AND METHODS

3.6.1 Objectives and Scope of the Evaluation

In 2004/2005, thirteen years after establishment, ASPREN was evaluated with a focus on its role in the syndromic surveillance for ILI. The first evaluation of ASPREN found it to be a simple, flexible, acceptable, and stable system. Recommendations for improvement were made around the need to enhance representativeness, specificity, and timeliness. Since the initial evaluation, major changes have been made to the system including electronic reporting, and systematic swab testing of patients presenting with ILI. Furthermore, this evaluation was performed pre-2009 pandemic H1N1.

A re-evaluation of ASPREN ten years since the inaugural assessment presents a fitting opportunity to determine how the changes have impacted upon certain system attributes. Compared to other influenza surveillance systems, ASPREN contains several unique qualities including national coverage, year-round operation, considerable flexibility, and surveillance for disease relatively early in the clinical course of infection. The results of an updated evaluation should consider these qualities and identify additional ways ASPREN may be utilized to address issues of public health importance including enhanced surveillance for pandemic influenza.

This evaluation was conducted using the Updated Guidelines for Evaluating Public Health Surveillance Systems developed by the Centers for Disease Control and Prevention (CDC), Atlanta. How the system is used and the system’s performance against each of the nine attributes listed in the CDC’s Guidelines are reported. The nine attributes are: simplicity, flexibility, data quality, acceptability, sensitivity, predictive value positive, representativeness, timeliness, and stability. Specifically, the performance of the system was evaluated against the system objectives as set by the Commonwealth. The purpose of this evaluation was to recommend system improvements that will allow ASPREN data to be used more effectively in understanding the epidemiology of influenza infection in Australia and in informing effective public health actions and interventions.

3.6.2 Data collection to evaluate the surveillance system

3.6.2.1 Engagement with ASPREN administration

From 25-29 May 2015, I visited ASPREN administration at the University of Adelaide’s Department of General Practice. My objective was to understand how the system operates.
3.6.2.2 Gauging acceptability of the system to general practitioners

ASPREN administrators conduct annual surveys to assess how acceptable the system is to enrolled general practitioners. These surveys allow GPs to give feedback on system improvement. ASPREN administration shared with me the results of the 2013, 2014, and 2015 annual surveys for a particular question: “is the amount of work that you have to undertake for ASPREN data collection acceptable?” I describe these data in terms of trends in GP responses over time accounting for GP membership status.

3.6.2.3 Engagement with key stakeholders

For this evaluation, I wanted to engage with Commonwealth influenza epidemiologists, jurisdictional epidemiologists who use ASPREN data as part of their work in understanding influenza epidemiology and initiating public health actions, representatives of SPNWA and VicSPIN to understand how ASPREN compares and contrasts to these systems, a representative from the WHO CC to understand the testing component of ASPREN, and epidemiologists who are not currently using but who may find a use for ASPREN data of other conditions.

Key stakeholders were identified with the assistance of the Department of Health. I conducted consultations with (Appendix 3-1):

- Three Commonwealth influenza epidemiologists, “Commonwealth”
- At least one influenza epidemiologist in each jurisdiction represented in the ASPREN system, except for Victoria and Western Australia (ACT (1), NSW (1), SA (1), Qld (1), Tas (1), NT (2)), “Jurisdictions”
- A representative from SPNWA, “SPNWA”
- Two representatives from VicSPIN, “VicSPIN”
- A representative from the WHO CC, “WHO CC”
- A Commonwealth vaccine-preventable disease (VPD) epidemiologist, “VPD”
- A representative from OzFoodNet, “OzFoodNet”

Consultations were performed either by face-to-face interview or via a designed survey administered through Survey Monkey online (Appendix 3-2). The responses were yes/no, multiple selection, or free text. The same survey was administered to Commonwealth and jurisdictional influenza epidemiologists. Separate surveys were tailored for each of SPNWA, VicSPIN, WHO CC, Commonwealth VPD epidemiologist, and OzFoodNet. Table 3-3 lists each attribute assessed (including usefulness), the stakeholder group consulted on each attribute and the consultation method.
The objective of the consultations was to understand how stakeholders perceive the operation of ASPREN with regard to each of the attributes.

**Table 3-3. List of attributes evaluated in stakeholder consultations, by stakeholder group and consultation method**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Stakeholder</th>
<th>Consultation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>Commonwealth Jurisdictions</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>SPNWA</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>VicSPIN</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>WHO CC</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>VPD*</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>OzFoodNet*</td>
<td>In-person</td>
</tr>
<tr>
<td>Simplicity</td>
<td>Commonwealth Jurisdictions</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>Commonwealth Jurisdictions</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
</tr>
<tr>
<td>Data quality</td>
<td>Commonwealth Jurisdictions</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VPD*</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>OzFoodNet*</td>
<td>In-person</td>
</tr>
<tr>
<td>Acceptability</td>
<td>Commonwealth Jurisdictions</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WHO CC</td>
<td>Online</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Commonwealth Jurisdictions</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
</tr>
<tr>
<td>Predictive Value Positive</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Representativeness</td>
<td>Commonwealth Jurisdictions</td>
<td>In-person</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
</tr>
<tr>
<td><strong>Timeliness</strong></td>
<td><strong>Commonwealth Jurisdictions</strong></td>
<td><strong>In-person Online</strong></td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td><strong>Commonwealth Jurisdictions</strong></td>
<td><strong>In-person Online</strong></td>
</tr>
<tr>
<td></td>
<td>SPNWA</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>VicSPIN</td>
<td>Online</td>
</tr>
</tbody>
</table>

NA=not applicable

*Usefulness was assessed for conditions other than ILI (pertussis, shingles, and chickenpox for VPD, and gastroenteritis, OzFoodNet)

### 3.6.2.4 Quantitative

To objectively measure system performance according to each of the attributes, various data sources were obtained and analysed (Table 3-4). ASPREN syndromic data (ILI and other conditions as well as consultation numbers) were provided by a Commonwealth epidemiologist. ASPREN virological data were obtained from ASPREN administration. Syndromic and virological data were analysed for the 2011-2015 period where appropriate. GP membership status and duration were obtained from ASPREN administration. Membership upgrade data were available from 2010 onwards and long-term GP membership data were available from 1993. For a comparison of ASPREN ILI notifications with laboratory-confirmed influenza notifications from the National Notifiable Diseases Surveillance System (NNDSS), NNDSS data for 2015 were extracted from Oracle Business Intelligence Discoverer on 24 May 2016.

As mentioned above, ASPREN has reporter representation in all jurisdictions except for WA, however SPNWA data are combined in ASPREN’s database. For my analyses, I exclude notifications/consultations/virological data from WA. When enumerating the number of reporters actively contributing to surveillance, I consider a reporter as one who has reported at least one consultation in at least one week of the year.

For representativeness, I calculated the target and actual number of GP reporters per population by the method currently recommended by the Australian Institute of Health and Welfare for remoteness classification – the Australian Standard Geographical Classification (ASGC) Remoteness Areas (RA).\(^{18}\) ASPREN administration use the RRMA classification to assign remoteness to GP reporters.
(Metropolitan (Metro), Rural and Remote) as per the contract for services. However, as the RRMA is an outdated method (superseded in 1999), there are no RRMA population data distributions for my calculations. The webpage used by ASPREN administration to determine remoteness by GP postcode, DoctorConnect: http://www.doctorconnect.gov.au/, has recently switched from using RRMA to RA categories. To keep terminology consistent for the purpose of this evaluation, the translation from the RA to the RRMA terminology is as follows: Major Cities are referred to as Metro areas, Inner and Outer Regional areas are referred to as Rural areas, and Remote and Very Remote areas are referred to as Remote areas. Target numbers were rounded up to the nearest integer. If the target number was below 1, the target was rounded to 1 to maintain geographical representativeness. Target and actual numbers of GP reporters were calculated nationally and for each jurisdiction for each year from 2012 to 2015. The population distribution of Australia by remoteness status was sourced from the Australian Bureau of Statistics (Category number: 3218.0). As 2015 data were not available, the population distribution by remoteness for 2014 was used for 2015 calculations.

When calculating predictive value positive, a positive influenza test result was considered one which was tested by SA Pathology to be positive for influenza A and/or influenza B. The “influenza season” is defined as the months of April to October inclusive.

Analyses were performed in Microsoft Excel 2010 and Stata version 13.

Table 3-4. Methods of quantifying system attributes by indicator used and data source

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Indicator</th>
<th>Data Source</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Simplicity</td>
<td>Method of GP reporting</td>
<td>GP enrolment data</td>
<td>2015</td>
</tr>
<tr>
<td>Flexibility</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Data quality</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Acceptability</td>
<td>• Total number of GP reporters • Long term GP members • Membership categories • GP member upgrades • Consistency of reporting through year • Swab testing rate</td>
<td>• Consultation data • GP enrolment data</td>
<td>• 2011-2015 • 1993-2015 • 2015 • 2006-2015 • 2015</td>
</tr>
<tr>
<td>Parameter</td>
<td>Data Source(s)</td>
<td>Time Period</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>GP catchment Influenza notifications Consultation data NNDSS</td>
<td>2011-2015</td>
<td></td>
</tr>
<tr>
<td>Predictive Value Positive</td>
<td>Influenza positive/ILI notifications Syndromic and virological data</td>
<td>2011-2015</td>
<td></td>
</tr>
<tr>
<td>Representativeness</td>
<td>Target and actual representation by remoteness (national and jurisdictional) Consistency in representation throughout the year Representativeness of swabbed ILI patients Indigenous completeness Consultation data/ABS Remoteness</td>
<td>2012-2015 2015 2015</td>
<td></td>
</tr>
<tr>
<td>Timeliness</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Stability</td>
<td>Proportional GP activity by week of year Consultation data</td>
<td>2015</td>
<td></td>
</tr>
</tbody>
</table>

NA=not applicable

### 3.7 RESULTS

To investigate whether the perceived objectives of the system at a jurisdictional level aligned with the national objectives, stakeholders were asked what they considered to be the objectives of ASPREN. Responses included: the early identification of ILI and laboratory confirmation of first cases presenting to GPs, to predict and monitor the flu season, to obtain a national view of influenza activity, to provide a profile of community/primary care presentations with ILI, and the early detection of flu and a range of other conditions from people attending GPs. These objectives aligned with the national objectives. When asked whether they thought ASPREN was achieving these objectives, 50% stated yes, 25% said...
no, and 25% were unsure. Of the nine system attributes, stakeholders were asked to indicate the three most important attributes required to achieve the objectives of ASPREN and the three attributes of the system that require the most improvement. Two attributes were ranked as the most important: representativeness and timeliness. Two attributes were ranked as requiring the most improvement: representativeness and stability.

3.7.1 Usefulness

The usefulness of ASPREN syndromic and virological surveillance to population health rather than to individual clinical management was considered here. All respondents (12 of 12) agreed that syndromic surveillance for influenza was important. Respondents stated that syndromic surveillance is useful to give an indication of ILI in the community and to alert authorities to a rise in circulating influenza before laboratory confirmed notification systems so that public messaging around vaccination can be implemented. One respondent stated that syndromic surveillance is free from bias associated with laboratory testing practices. It was recognised by multiple respondents that syndromic surveillance is an important complement to data collected from other surveillance systems; it contributes to the overall knowledge of influenza epidemiology and is helpful to interpret the clinical severity of the season.

All respondents stated that they interpret ASPREN data in combination with other influenza surveillance systems rather than in isolation. When asked whether ASPREN data complement, fill gaps or overlap that of other influenza surveillance systems, the majority of responses were that ASPREN data complement and fill gaps. ASPREN data are used in conjunction with other data sources to indicate the beginning of the influenza season and then to monitor and support/validate trends in ILI and influenza virological data over time. Other identified uses for ASPREN data included informing public health action and prevention strategies, evaluating these strategies (e.g. vaccine effectiveness), and as a component of pandemic preparedness and response. Of eight respondents, 5 (63%) use ASPREN data year-round, and 3 (38%) only use data during the flu season.

Stakeholders were asked to rate the degree of usefulness of ASPREN syndromic and virological data on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of seven respondents, the average rating of usefulness of ASPREN syndromic data was 1.9 and of seven respondents, the average rating of usefulness of ASPREN virological data was 2.3. A representative from the WHO CC stated that virological samples collected through ASPREN were highly valued and useful due to the high quality of the collected specimens and the rich patient data that accompanies the samples. These data contribute to informing vaccine effectiveness estimates and vaccine strain selection. The WHO CC
representative would like to see a greater number of samples collected for influenza surveillance through ASPREN.

Stakeholders were asked whether ASPREN data are presented to them in a way they find useful. Of seven respondents, 3 (43%) said yes, 3 (43%) said no, and 1 (14%) was unsure. Of seven respondents, 5 (71%) thought the presentation of ASPREN data could be improved to increase its usefulness. One respondent stated that they would like denominator data for swab testing and one respondent would like a consolidated report with information tailored to specific stakeholder groups sent at a regular interval. One respondent stated that due to small numbers of ILI notifications, a graph with ILI rate per 1,000 consultations should be provided with confidence intervals around each weekly estimate.

Of the eight respondents who received ILI data, 7 (88%) used these data. Of the seven respondents who received virological data (influenza positive test results), 6 (86%) used these data. Of the six respondents who received virological data (influenza subtypes), five (83%) used these data. Of the three respondents who received data for the syndromic surveillance of other conditions other than ILI, none used these data. Additionally, of eight respondents, seven could not identify any team member that used syndromic data for the other conditions other than ILI. One of the eight respondents was unsure whether any other team member used syndromic data for the other conditions. Of the four respondents who received data for the virological surveillance of other respiratory pathogens other than influenza, none used these data. When asked how many members of their team used ASPREN data, responses ranged from one to 20 team members.

Lastly, stakeholders were asked how their work would be affected if ASPREN data were no longer available to them. Of nine respondents, five (56%) stated that there would be minimal impact and three (33%) stated a significant impact including a lack of perspective about seasonal influenza severity, an overreliance on notification data which may result in incorrect public messaging, and a lack of knowledge of dominant circulating subtype/lineage if influenza subtype data were not available. One (11%) respondent was unsure.

3.7.1.1 Use in the pandemic
Stakeholders were specifically asked whether ASPREN syndromic data were useful during the 2009 H1N1 pandemic. Of six respondents, 3 (50%) said yes, 1 (17%) said no, and 2 (33%) were unsure. Those who used the data during the pandemic said that it contributed to overall influenza surveillance, was particularly important when the capacity for laboratory influenza testing was variable or limited, and gave an accurate estimate of the proportion of the population infected. Poor representation at a jurisdictional level and timeliness were reasons why ASPREN syndromic data were not used by some
during the pandemic. There was a general consensus among respondents that in its current form, ASPREN syndromic data could not detect localised outbreaks. Representation would need improvement and the number of GP reporters would need to increase for the system to have this capability.

3.7.2 Simplicity

The simplicity of data input, transmission, collation, reporting, and use is considered. The input and transmission of data occur separately for syndromic and virological data and may involve automated or manual processes. Where automated processes occur, the system is relatively simple. For 61% of GPs in 2015, syndromic data input was automated through the use of the Canning data extraction tool. Installation of the Canning Flu Tool is an opt-out process for newly recruited GPs. Automated syndromic data transmission to DMAC occurred for 98% of GPs in 2015 where Canning extraction and web-based data entry occurred. A small percentage (2%) of GPs in 2015 input and transmitted syndromic data manually using paper-based templates. The input and transmission of virological data is mainly a manual process.

The highest degree of complexity in the system occurs during data collation which is largely a manual process performed by ASPREN administration. Here, ASPREN and VicSPIN syndromic data are manually aggregated and then combined with virological data for ASPREN and SPNWA which are emailed as separate spreadsheets. Data aggregation is performed to report syndromic and virological data for all jurisdictions.

Stakeholders were asked to rate the simplicity of syndromic and virological data on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of seven respondents the average rating for the simplicity of syndromic data was 2.4. Of five respondents the average rating for the simplicity of virological data was 2.2. Stakeholders were also asked whether a significant amount of time was required to interpret and incorporate ASPREN data into their work. Of seven respondents, 29% stated that it took a significant amount of time to interpret ASPREN data and 14% stated it took a significant amount of time to incorporate ASPREN data into their work.

3.7.3 Flexibility

Flexibility for ASPREN refers to the relative ease of the system to allow for the surveillance of new disease syndromes or targeted disease surveillance, particularly during an epidemic or pandemic. It may also refer to the scalability of the system, i.e. its ability to deal with large numbers of cases. It is important that ASPREN is a flexible system in order to meet the first objective as set by the Commonwealth. Stakeholders were asked their opinion of the degree of flexibility of the ASPREN
system on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of seven respondents, the average rating of flexibility was 2.1.

Adding the surveillance of a new disease syndrome to the system would require GP acceptance and feasibility would depend on resources, funding, and whether laboratory testing would be an additional component. Past examples of flexibility include the addition of syndromic surveillance for pertussis in 2013 and the addition of new fields to collect information on comorbidities and vaccination histories for patients with ILI in 2014. System administrators found that the web reporting system was very flexible to amend however this would only target those GPs who used this method of data entry (37% of GPs in 2015). The Canning Flu Tool was less flexible to modify and there is an estimated minimum two week turnaround for the addition of a new condition to the data extraction system. This estimate does not include the time required to train GPs in syndrome coding. Additional complexity and time to implementation would occur if laboratory testing was added to syndromic surveillance.

For scalability, due to the large amount of manual data collation, there is an upper limit in terms of human resources. For ASPREN staff, 2014 was a big year in terms of ILI notifications and required the recruitment of a new staff member. Upper limits to the number of samples collected and tested would depend on funding and laboratory resources.

3.7.4 Data quality
ASPREN administration audit data quality through both automated and manual checks. Automated checks are built into the system and include checks for record duplication and unknown GP identifiers. A substantial amount of time is spent on manual checks which include ensuring concordance between pathology forms and reports generated by the laboratory as well ensuring each patient selected for sampling is recorded as an ILI notification. There are additional financial incentives for GPs to record patient data completely and correctly.

Stakeholders were asked their opinion of the degree of quality of ASPREN syndromic and virological data on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of seven respondents, the average rating of the quality of syndromic data was 2 and of six respondents, the average rating of the quality of virological data was 2.3. There has been a recent issue, likely due to inappropriate GP coding, where a number of ILI presentations were not extracted by the Canning Flu Tool, resulting in larger numbers of patients swabbed than ILI notifications. The error in the Canning Flu Tool was addressed and ILI notifications were retrospectively updated. However, one respondent commented that ILI notifications for the most recent 2-3 weeks were not complete, making interpretation difficult. Another respondent
noted that consultation data and ILI notification data did not always correlate with each other, making rate calculation difficult.

Epidemiologists at the Commonwealth were asked about the data quality and thus the utility of the syndromic data collected for gastrointestinal illness, pertussis, chickenpox, and shingles. Overall it was concluded that the data for syndromes other than ILI were too poor in quality to be useful or did not add value to data from surveillance systems that are already used. The reasons for this conclusion depended on disease. Poor data quality was either due to small numbers of cases reported, surveillance for a syndrome that was non-specific and gave too much ‘background noise,’ or the absence of laboratory confirmation of disease for non-specific syndromes.

3.7.5 Acceptability
For 2015, results of an annual survey conducted by ASPREN administration showed that of 122 GPs who answered the question, 113 (93%) agreed or strongly agreed that the amount of work they have to undertake for ASPREN data collection is acceptable. The remaining 9 GPs stated that they neither agreed nor disagreed that the amount of work is acceptable. Of these 122 GPs, 105 (86%) are Platinum/Platinum Plus members, 14 (11%) are Gold members, 2 (2%) are Silver members, and 1 (1%) is of unknown membership status. Of 92 GPs who answered this question in two or more annual surveys (2013, 2014, and/or 2015), the level of acceptability remained stable for 62 (67%) GPs, declined for 18 (20%), and improved for 12 (13%). Here, declining acceptability means moving from ‘strongly agree’ to ‘agree’, ‘strongly agree’ to ‘neither agree nor disagree’, or ‘agree’ to ‘neither agree nor disagree.’

The number, length and category of GP enrolment as well as the routine provision of data by GPs are used to indicate the acceptability of the system. Over the last five years there has been a steady increase in the number of GP reporters (Table 3-5).
Table 3-5. Number of ASPREN GP reporters per year, 2011-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of GP reporters</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>96</td>
</tr>
<tr>
<td>2012</td>
<td>109</td>
</tr>
<tr>
<td>2013</td>
<td>135</td>
</tr>
<tr>
<td>2014</td>
<td>166</td>
</tr>
<tr>
<td>2015</td>
<td>175</td>
</tr>
</tbody>
</table>

As at the end of 2015 (from 1993), 77 general practitioners are considered long-term members (enrolled for five or more years). Of the 205 enrolled GPs in 2015, 15 (7%) are Silver members, 21 (10%) are Gold members, and 169 (82%) are Platinum or Platinum Plus members. From January 2010 to June 2015, there were more GP reporter upgrades (voluntary upgrade in category of enrolment, e.g. Silver to Gold) than downgrades: 27 versus 12, respectively.

For 2015 there were a total of 175 GP reporters. The average number of weeks in the year that a GP reported was 41 with a range of 2 to 52 weeks. If one allows 4 weeks annual leave, one week sick leave and 2 weeks for continuing education, this gives a target of 45 reporting weeks for each GP as a marker of consistent reporting. In 2015, 101 (58%) of GPs consistently reported throughout the year. Figure 3-4 shows for 2015 the proportion of the total number of GP reporters who actively reported by week of the year. The weekly minimum proportion of active reporters was 54% in week 1 with a maximum of 89% in week 34.
Weekly sample numbers submitted by ASPREN GPs and the proportion of ILI patients sampled have remained relatively stable between 2011 and 2015 (Table 3-6).

**Table 3-6. Swab testing data per year for ASPREN GPs (minus SPNWA), 2011-2015.**

<table>
<thead>
<tr>
<th></th>
<th>Total swabs tested</th>
<th>Weekly Min.</th>
<th>Weekly Max.</th>
<th>Mean</th>
<th>95% CI</th>
<th>Total ILI notifications</th>
<th>% ILI Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1,252</td>
<td>0</td>
<td>74</td>
<td>24</td>
<td>18-30</td>
<td>3,518</td>
<td>36</td>
</tr>
<tr>
<td>2012</td>
<td>1,770</td>
<td>1</td>
<td>145</td>
<td>34</td>
<td>23-45</td>
<td>5,214</td>
<td>34</td>
</tr>
<tr>
<td>2013</td>
<td>1,338</td>
<td>2</td>
<td>76</td>
<td>26</td>
<td>21-30</td>
<td>4,327</td>
<td>31</td>
</tr>
<tr>
<td>2014</td>
<td>1,925</td>
<td>2</td>
<td>126</td>
<td>37</td>
<td>27-47</td>
<td>6,144</td>
<td>31</td>
</tr>
<tr>
<td>2015</td>
<td>1,630</td>
<td>0</td>
<td>101</td>
<td>31</td>
<td>22-40</td>
<td>5,413</td>
<td>30</td>
</tr>
</tbody>
</table>

3.7.6 Sensitivity

For influenza surveillance, sensitivity is the ability of a system to detect all cases of influenza in Australia. Due to the range in severity of influenza virus infections and the multiple factors that influence health-care seeking behaviour, ASPREN is not designed to detect all infections in the community. Instead, the sensitivity of ASPREN should be thought of as the proportion of influenza virus infections that are detected in persons seeking primary health care for a clinically consistent...
illness. The sensitivity of ASPREN thus relies on the coverage of the GP network, the sensitivity of the ILI case definition to detect influenza, and the correct coding/data input of the reporting GP.

As a system comparison, in 2015 there were 94,564 cases of laboratory confirmed influenza notified to the NNDSS versus 5,413 notifications of ILI and 480 influenza test positives through ASPREN for all jurisdictions excluding WA. For the ASPREN system in 2015, the average number of total consultations recorded per week was 13,192 which equates to 0.06% of the Australian population. For 2015 ASPREN GPs saw a combined patient population of 685,991, approximately 2.9% of the Australian population. In a year, approximately 85% of the Australian population claim for at least one GP service from Medicare. The number of laboratory confirmed influenza infections detected through ASPREN surveillance constitute a small proportion (0.51%) of the number of nationally notified cases in a year and the system captures only a small proportion of the health-seeking population. Being a sentinel system, ASPREN is not designed to enrol every GP in the country. Thus, it is important to enrol a sample of GPs who service patients that are demographically representative of persons seeking healthcare in Australia.

The ILI case definition used (cough, fever, and fatigue) has been shown in the Australian sentinel GP setting to have a sensitivity ranging from 43.5% to 75.1% and was recommended as a national ILI case definition due to its simplicity and relatively good positive predictive value for laboratory-confirmed influenza. It is up to the GP’s discretion as to whether a patient meets this case definition; ASPREN administration do not audit GP adherence to the case definition. For a person presenting with ILI to be detected by the system, GPs must either use the correct coding (Canning Flu Tool) or manually input data (Web reporting, paper). A study from NSW examined the sensitivity and specificity compared to professional opinion of a list of codes and text extracted by the Canning Flu Tool to detect ILI. The sensitivity of the Canning Flu Tool was 96.3% and the specificity 99.7%. It is unknown whether the same list of codes and text are used in ASPREN syndromic surveillance however similar values would be expected. ASPREN administration audit GP activity once every three months. If a GP is found not to have reported an ILI for some time, the GP will be contacted to confirm if they have stopped reporting or whether they are using incorrect coding. If the latter, the GP will be retrained in correct coding.

In addition to the above, the sensitivity of ASPREN syndromic data may be thought of as the ability of the system to detect meaningful changes in ILI rates. Survey respondents indicated that they assessed trends in rates of ILI at a community, jurisdictional and/or national level. Currently there are no standard baselines or thresholds to signal significant changes in ILI rates and no standardised way
to compare ASPREN syndromic data with data from other influenza surveillance systems. Stakeholders were asked their opinion of the degree of sensitivity of ASPREN syndromic data on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of six respondents, the average rating of sensitivity was 1.7. The majority of respondents stated that the numbers of ILI notifications are too small and that this impacted upon the sensitivity of both syndromic and virological surveillance. One respondent stated that currently the system is not sensitive enough to reliably detect outbreaks. Stakeholders were also asked whether they had confidence in the signals generated by ASPREN data. In other words, if an indicator generated using ASPREN data crosses a defined threshold, how much confidence do stakeholders have that this signal is meaningful? Of eight respondents, 3 (38%) said yes, 3 (38%) said no, and 2 (25%) were unsure. Respondents generally stated that they were confident in longer term trends at a national level – extremes and direction – rather than actual values for week to week. Poor representativeness and a lack of threshold values were given as the main sources of decreased confidence.

3.7.7 Predictive value positive

Representative sampling and laboratory testing of ILI patients was introduced in 2010 to quantitatively determine the predictive value of ILI for influenza activity. For ASPREN data, predictive value positive (PVP) is the probability that a patient presenting to a GP with ILI is unwell due to infection with influenza. PVP will depend upon the specificity of the case definition for ILI (fever, cough and fatigue) as well as the prevalence of influenza and non-influenza pathogens in the community. Table 3-7 shows how ASPREN data are used to calculate PVP. PVP is calculated in Table 3-7 as the number of positive influenza tests divided by the total number of ILI cases. On average, considering data for the last five years, for every 12 patients presenting to a GP with ILI, one will be confirmed as infected with influenza in the ASPREN system.
Table 3-7. Estimating predictive value positive for ASPREN data. Data are included for all jurisdictions except for Western Australia.

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ILI presentations</strong></td>
<td>3,518</td>
<td>5,214</td>
<td>4,327</td>
<td>6,144</td>
<td>5,413</td>
</tr>
<tr>
<td><strong>ILI eligible for swabbing</strong></td>
<td>3,475</td>
<td>5,189</td>
<td>4,315</td>
<td>4,765</td>
<td>5,057</td>
</tr>
<tr>
<td>(%) ILI presentations</td>
<td>(99%)</td>
<td>(99%)</td>
<td>(99%)</td>
<td>(78%)</td>
<td>(93%)</td>
</tr>
<tr>
<td>Number of swabs tested</td>
<td>1,252</td>
<td>1,770</td>
<td>1,338</td>
<td>1,925</td>
<td>1,630</td>
</tr>
<tr>
<td>(%) ILI eligible for testing</td>
<td>(36%)</td>
<td>(34%)</td>
<td>(31%)</td>
<td>(40%)</td>
<td>(32%)</td>
</tr>
<tr>
<td>Number of swabs positive for influenza</td>
<td>372</td>
<td>673</td>
<td>266</td>
<td>497</td>
<td>480</td>
</tr>
<tr>
<td>(%) Number of swabs tested</td>
<td>(30%)</td>
<td>(38%)</td>
<td>(20%)</td>
<td>(26%)</td>
<td>(29%)</td>
</tr>
<tr>
<td>Predictive value positive (of total ILI)</td>
<td>11%</td>
<td>13%</td>
<td>6%</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>~1:9</td>
<td>~1:8</td>
<td>~1:17</td>
<td>~1:13</td>
<td>~1:11</td>
</tr>
</tbody>
</table>

(ILI presentations to Platinum/Platinum plus GPs)

As predicted, the PVP for ASPREN data is higher during the flu season compared to outside the flu season (Table 3-8). Here, the denominator is the total number of swabs tested within and outside the flu season. A patient presenting to a GP with ILI during the flu season has a much higher likelihood of influenza infection compared to outside the flu season.

Table 3-8. Predictive value positive within and outside of flu season

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>30%</td>
<td>38%</td>
<td>20%</td>
<td>26%</td>
<td>29%</td>
</tr>
<tr>
<td>Within flu season</td>
<td>34%</td>
<td>40%</td>
<td>22%</td>
<td>28%</td>
<td>31%</td>
</tr>
<tr>
<td>Outside flu season</td>
<td>11%</td>
<td>15%</td>
<td>13%</td>
<td>10%</td>
<td>7%</td>
</tr>
</tbody>
</table>
3.7.8 Representativeness

Stakeholders were asked what they thought ASPREN syndromic data should be representative of. Of 6 respondents, 2 used the word ‘community’ in their response, one thought it should be nationally representative, one stated it should be representative of ILI cases that present to general practice, one stated it should be representative by geographical area (urban, rural and remote) and also by age, and one thought it should be representative at a jurisdictional level. A lack of perceived representation at a jurisdictional level is a major reason stated for low respondent confidence in the quality of ASPREN syndromic data. Stakeholders were asked whether they used in-house methods to measure representativeness of ASPREN data. Of eight respondents, 1 (13%) stated yes, 6 (75%) stated no, and 1 (13%) was unsure. Stakeholders were asked to rate the degree of representativeness of ASPREN syndromic data according to what they thought the data should be representative of. Ratings were given on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of six respondents, the average rating of representativeness of ASPREN syndromic data against targets set by each respondent was 1.3. Respondents thought there were not enough GPs in the system and those that do report are concentrated geographically. One respondent suggested the use of confidence intervals to illustrate the degree of uncertainty in the data. Currently, ASPREN administration does not report how enrolled GPs are representative of all GPs in Australia.

ASPREN administrators audit GP representation annually and publish the results in an annual report. Representativeness in these reports is presented as the number of enrolled GPs compared to the target number of GPs by jurisdiction. There is no detail of how targets are met by remoteness. Figure 3-5 shows ASPREN administration’s report for representation for 2014. ASPREN administrators conclude from this analysis that all jurisdictions are over-represented with the exception of Queensland and Victoria. The report states that no practices were actively recruited from Victoria due to the surveillance activities being undertaken by VicSPIN.
It is my opinion that representation should be measured by the number of GPs reporting rather than enrolled and should be clearly shown by remoteness classification against the targets as per the contract. Table 3-9 shows the target versus actual numbers of GP reporters by year from 2012 to 2015 nationally and by jurisdiction, stratified by remoteness classification. It is important to note here that I have used an updated method of assigning remoteness compared to what ASPREN administration use as per the contract, for reasons stated in the Methods. Although targets and actual GP numbers may be different to what ASPREN administration calculates, I would not expect significant differences between the two methodologies. In the ASPREN annual report for 2014, there was no transparency in how multiple GPs from a single practice were accounted for. Stakeholders do not receive practice details for each GP and thus cannot factor this issue into their analyses.
Table 3-9. Annual target versus actual numbers of GP reporters nationally and per jurisdiction by remoteness classification, 2012-2015

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2014</th>
<th>2013</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Actual</td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td><strong>Australia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>83</td>
<td>116</td>
<td>83</td>
<td>105</td>
</tr>
<tr>
<td>Rural</td>
<td>127</td>
<td>53</td>
<td>127</td>
<td>54</td>
</tr>
<tr>
<td>Remote</td>
<td>11</td>
<td>6</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td><strong>ACT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Rural</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Remote</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rural</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>NSW</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>28</td>
<td>56</td>
<td>28</td>
<td>54</td>
</tr>
<tr>
<td>Rural</td>
<td>38</td>
<td>15</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>Remote</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Qld</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>15</td>
<td>18</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Rural</td>
<td>33</td>
<td>26</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Remote</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>SA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>6</td>
<td>28</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Rural</td>
<td>8</td>
<td>5</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Remote</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Tas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Rural</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Remote</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>22</td>
<td>9</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>Rural</td>
<td>27</td>
<td>0</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>Remote</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

*Red numbers indicate where targets are not met

For an assessment of trends from week to week, it is my opinion that representation should also be maintained from week to week. Table 3-10 shows for 2015, the number (and %) of weeks in the year that representation was met or exceeded.
Table 3-10. Number (%) weeks of the year, overall and within and outside the flu season, where representation was met or exceeded, 2015.

<table>
<thead>
<tr>
<th></th>
<th>Total (%)</th>
<th>Within season (%)</th>
<th>Outside season (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Australia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>50/52 (100)</td>
<td>31/31 (100)</td>
<td>19/21 (90)</td>
</tr>
<tr>
<td>Rural</td>
<td>0/52 (0)</td>
<td>0/31 (0)</td>
<td>0/21 (0)</td>
</tr>
<tr>
<td>Remote</td>
<td>0/52 (0)</td>
<td>0/31 (0)</td>
<td>0/21 (0)</td>
</tr>
<tr>
<td><strong>ACT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>51/52 (98)</td>
<td>31/31 (100)</td>
<td>20/21 (95)</td>
</tr>
<tr>
<td>Rural</td>
<td>0/52 (0)</td>
<td>0/31 (0)</td>
<td>0/21 (0)</td>
</tr>
<tr>
<td><strong>NT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>43/52 (83)</td>
<td>27/31 (87)</td>
<td>16/21 (76)</td>
</tr>
<tr>
<td>Rural</td>
<td>0/52 (0)</td>
<td>0/31 (0)</td>
<td>0/21 (0)</td>
</tr>
<tr>
<td>Remote</td>
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Representativeness should also be considered for virological data. Ideally, patients that are selected for a virological test should be representative of all ILI patients presenting to ASPREN GPs. For the 175 GP reporters (regardless of classification) in 2015, 41% were from NSW, 25% from Qld, 20% from SA, 5% from Vic, 4% from Tas, 3% from ACT, and 2% from NT. By remoteness, 66% were from a metropolitan area, 30% from a rural area, and 3% from a remote area. For the 144 of 175 GPs in 2015 that were enrolled in the system to swab (Platinum/Platinum Plus reporters), 37% were from NSW, 26% from Qld, 22% from SA, 6% from Vic, 5% from Tas, 3% from ACT, and 1% from NT. By remoteness, 65% were from a metropolitan area, 32% from a rural area, and 3% from a remote area.

Figures 3-6 to 3-8 show for 2015, the proportions by sex, jurisdiction and age-group, respectively of the total number of ILI notifications and total number of swabs tested. Virological sampling appears to be representative for sex but not for jurisdiction or age-group. Persons presenting with ILI to ASPREN GPs are more likely to be sampled in NSW, NT, SA, Tas and less likely in ACT, Qld, and Vic. Virological sampling appears to be representative for ILI patients less than 1 year old, however ILI patients from 1 to 19 years are under-sampled and those aged 20 years and over are over-sampled.
Figure 3-6. Proportion by sex of ILI notifications and patients selected for sampling, 2015

Figure 3-7. Proportion by jurisdiction of ILI notifications and patients selected for sampling, 2015
Aboriginal and/or Torres Strait Islander persons are identified as at-risk persons for complications associated with influenza virus infection. Currently, the only way Indigenous status of patients could be determined was if it was recorded on the pathology form, i.e. only those ILI patients who were selected for swabbing. In 2014, the completeness of the Indigenous status field on ASPREN pathology forms was 39% and in 2015, 57%.

3.7.9 Timeliness
Syndromic data from GPs who report via the web may be accessed in real-time and for those who report via the Canning Flu Tool, data are uploaded weekly. ASPREN administration reports useful and audited syndromic and virological data to the Commonwealth every week on a Thursday. Currently syndromic data are only useful on a weekly basis as GPs report consultation denominator data at the end of each week and ASPREN administrators manually audit syndromic data against virological data once per week. Thus, the maximum lag time between a presentation of ILI and reporting by ASPREN administration is 10 days with a minimum of four days.

Virological data may be divided into two categories based on timeliness. The first group is notifications of influenza type and subtype, and other respiratory pathogens, determined by PCR alone. The second group are data related to virus characteristics such as lineage and clade, antiviral resistance and vaccine matching determined by virus isolation and molecular methods. The first group of data are provided to ASPREN administration on a weekly basis for incorporation with syndromic data in the weekly
Commonwealth report. These data are reported by week number (1-52) based on date of referral of swab by GP to the laboratory. These data include swab testing results generated through ASPREN and SPNWA. Often SPNWA swab testing results arrive after the deadline for incorporation into the weekly report. The second group of data are less timely and are generated at irregular intervals; more frequently during the flu season.

Stakeholders were asked to rate the degree of timeliness of ASPREN syndromic and virological data on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of seven respondents, the average rating of timeliness of ASPREN syndromic data was 2.4 and of five respondents, the average rating of timeliness of ASPREN virological data was 2. Stakeholders were also asked whether data are delivered in a time frame that allows useful incorporation of the information into their work. Of eight respondents, four (50%) answered yes, two (25%) answered no, and two (25%) were unsure. One respondent commented that positive influenza diagnoses are reported in a timelier manner through the notifiable disease surveillance system.

3.7.10 Stability
The ability of ASPREN administration to consistently report nationally representative syndromic and virological data relies on the stability of: GP reporters from week to week, data extraction methods, administrative workforce, laboratory support, and the collaborative relationship between ASPREN, SPNWA, and VicSPIN administrators. Stakeholders were asked to rate the stability of the ASPREN system on a scale of 1 to 3: 1=poor, 2=moderate and 3=good. Of six respondents, the average rating of stability was 2.7. As discussed under Acceptability, for 2015, of a target 45 weeks of the year for consistent reporting, only 58% of GPs consistently reported throughout the year.

In early 2015, ASPREN administrators identified instances where overall swab testing rates exceeded 100%. This indicated that the Canning Flu Tool was not completely extracting all ILI notifications. The likely reason for this was GPs coding for ILI in a way that the extraction tool could not recognise. This resulted in inaccurate ILI rates and a large amount of additional work for ASPREN administrators who were required to compare ILI notifications with swab testing data and manually enter any missing ILI notifications into the system. This problem was not resolved until late 2015. Although this issue has been resolved it highlights how the stability of the system hinges on the workings of the extraction tool which is outsourced to a single programmer.

Representatives of SPNWA and VicSPIN did not identify any likely risks to their ongoing collaborative relationship with ASPREN administration. Furthermore, according to the WHO CC representative, ongoing laboratory support is likely to continue in the future as swabs collected through
ASPREN surveillance are highly valued for their contribution to understanding circulating strain diversity, antiviral resistance and vaccine effectiveness estimates.

### 3.8 DISCUSSION

In this evaluation of ASPREN I have assessed how the system performs against each of nine attributes. Below is a summary of each attribute including what is required to meet the system objectives as set by the funding body, the Commonwealth, how stakeholders perceive system operation, and how the system actually operates. As a reminder, the objectives of the ASPREN system are:

<table>
<thead>
<tr>
<th>Objective</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>To provide a flexible system for the collection of nationally representative data on disease syndromes in the community</td>
</tr>
<tr>
<td>2.</td>
<td>To act as a nationally representative indicator of influenza activity (through ILI surveillance) in the community in real-time</td>
</tr>
<tr>
<td>3.</td>
<td>Through systematic and representative sampling and testing of ILI patients, quantitatively determine the predictive value of ILI for influenza activity</td>
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</tbody>
</table>

#### Simplicity

Ideally ASPREN would be a simple system with minimal amount of effort required for data input, compilation and reporting. Stakeholders perceive the simplicity of ASPREN syndromic and virological data to be moderate-good (2.4/3) and moderate (2.2/3), respectively. With the introduction of the laboratory testing component in 2010 and the need to combine syndromic data from SPNWA to achieve national coverage, there is considerable complexity to the ASPREN system. Currently administrative personnel are not being used efficiently as a large proportion of time is taken to cross-check laboratory data with syndromic data rather than to improve the system. There will be an inbuilt function in the new ASPREN system rebuild to audit swab tests against ILI notifications and automatically fill in any missing data.

#### Flexibility

The flexibility of the system to collect data on disease syndromes in the community is the first objective of ASPREN. As a national system that operates year-round, ASPREN would play a key role in the response to a pandemic, including pandemic influenza, if detected in Australia or overseas, or if a new influenza strain occurred in animals in Australia or New Zealand. In such an event, the system would need to be flexible both to the changing surveillance needs in a pandemic (e.g. case definitions and
requirement for sample collection) as well as in the amount of data the system would need to handle. Stakeholders consider the flexibility of the ASPREN system to be moderate (2.14/3). In its current state, there would be significant challenges to the scalability of the system; namely the amount of manual work currently performed by administrators would impede the efficient operation of ASPREN during a pandemic. A more automated means of data compilation would be required to increase flexibility. However, the relationship of ASPREN with reporting GPs and to the medical establishment should not be underestimated as a receptive network for information dissemination during a pandemic.

Data quality

The ASPREN system has certain properties that give the potential to provide good quality data. The ILI syndrome is classified by a health professional rather than self-reported as occurs in such systems as Flutracking. Also, ASPREN syndromic and virological data include denominator data: the number of consultations and the number of ILI patients swabbed (with a consistent sampling rate) unlike systems such as NNDSS. Stakeholders perceive the quality of ASPREN virological data to be higher than syndromic data (moderate to good (2.3/3) vs. moderate (2/3)). Data collected for the conditions other than ILI (gastroenteritis, chicken pox, shingles, and pertussis) were not used by jurisdictional or Commonwealth epidemiologists and were deemed too poor quality to be useful in consultation with OzFoodNet and VPD representatives. Depending on disease, data were considered too poor quality due to either small numbers, a lack of laboratory confirmation, or too much non-specific background ‘noise.’ Virological data for respiratory pathogens other than influenza were not used by those surveyed who receive these data or their team members. It would be worthwhile to explore the utility of these data, for example, in using trends in other respiratory pathogens to predict the onset of the flu season. The collection of syndromic data other than ILI and the analysis of samples for pathogens other than influenza do not appear in the Commonwealth’s contract as an objective of ASPREN.

Acceptability

The short and long term success of ASPREN hinges on the acceptability of the system to those who provide syndromic and virological data: the GPs and the laboratories. Results of annual GP satisfaction surveys and analysis of enrolment data indicate that the system is acceptable and GPs are engaged and active participants. From 2011 to 2015 there has been a steady increase in the number of GPs providing data to the system, the majority (82% in 2015) of enrolled GPs op-in to be Platinum members which requires the extra effort of sampling, GP activity for 2015 generally appeared higher in the influenza season, and from 2011 to 2015, the annual proportion of ILI patients swabbed remained above the target 20% (range from 30 to 36%). It is important to note here that the current contracted allocation...
of swabs is 1,400 per year. Swabs beyond this allocation are subject to available funding and require variation to the existing contract. Better management of the testing protocol would ensure more appropriate use of resources. According to a WHO representative, samples collected through ASPREN are highly valued by the WHO CC as they are high quality, less biased as they are systematically taken from ILI patients at primary care, and are accompanied with rich patient information.

Sensitivity

As a syndrome without the need for laboratory confirmation, surveillance for ILI at the level of primary care is conducted to provide an early indication of increased disease activity. It has been shown by a number of analyses that ASPREN ILI data provide an earlier indication of the onset of the influenza season compared to data collected by hospitals or laboratories.\cite{16,25} Stakeholders’ perception of the sensitivity of ASPREN syndromic data is poor-moderate (1.7/3). It is not an objective for ASPREN to detect the onset of outbreaks or to detect newly emerged influenza strains; it is designed to indicate the level of influenza activity in the community at a national level. Thus in its current state, ASPREN should not be considered an early ‘warning’ system in that it is not sensitive enough to detect discrete geographical increases in activity, rather once activity exceeds a threshold, ASPREN syndromic data give an early indication of established influenza transmission in the community before systems that are designed to detect influenza disease of greater severity. If ASPREN was to be re-designed to be sensitive enough to detect localised outbreaks, there would need to be an increase in the number of GP reporters, perhaps in areas or practices with high ILI throughput, and perhaps a change to the case definition (but at the expense of specificity and difficulty in comparing data from previous years). The upgraded Canning Flu Tool will recognise a greater repertoire of words/phrases that distinguish ILI – thus the system will be more sensitive to detect ILI patients.

It may be more relevant to think of the sensitivity of ASPREN as its ability to detect ‘meaningful’ changes in the rates of ILI and the proportion of influenza positive tests. ‘Meaningful’ may be objectively determined by applying standardised baselines and thresholds to ASPREN syndromic and virological data. Currently there are no standardised baselines or thresholds applied to ASPREN data nor is there a standardised way of interpreting ASPREN signals in the context of other influenza surveillance systems (e.g. FluCAN, NNDSS). There are various methods of calculating such cut-offs\cite{26,27} and the application of baselines and thresholds are recognised by the World Health Organization’s Surveillance Standards for Influenza as improving the accuracy of clinical diagnosis, the appropriate use of antiviral medication, and the uptake and timeliness of seasonal influenza vaccines.\cite{28} The application of baselines and thresholds would really only be useful if there were agreed
public health actions taken once a baseline or threshold was crossed. At a national level such public health actions may include public health messaging focused on enhanced hand hygiene and encouraging vaccination. At a jurisdictional level these actions may include enhanced surveillance or testing for influenza, implementing enhanced infection control in high risk areas including hospitals, and in assisting health care settings to plan for increased absenteeism and increased admissions.

Currently, it is not possible to calculate rates of ILI by age or sex as denominator data are aggregated. The proportion influenza test positive may be calculated by age and sex however small numbers preclude meaningful categorisation and analysis of data. The weekly ASPREN report to the Commonwealth does not provide a break-down of ILI notifications by age-group or sex. For influenza surveillance it is important to detect changes from what is expected. Influenza subtype can have a significant impact on the demographics of patients presenting to primary care.\textsuperscript{29} Sentinel GP influenza surveillance in New Zealand collects age-specific patient population denominators for consultation rate calculations.\textsuperscript{30} The WHO Surveillance Standards for Influenza recommend reporting ILI cases grouped by standard age groups (ideally as a rate by age-group) and the proportion of each group positive for influenza.\textsuperscript{28}

\textit{Predictive Value Positive}

The introduction of systematic sampling in 2010 allows the calculation of the predictive value of ILI for influenza as reflected in the third Objective. In 2015, approximately 1 in every 12 patients presenting with ILI to an ASPREN GP were confirmed to be infected with influenza virus. This predictive value compares favourably to values reported by Flutracking of 1 in 66 in 2015.\textsuperscript{31} The combination of a more specific case definition and health professional classification of ILI would contribute to the greater predictive value of ILI for influenza infection in ASPREN.

\textit{Representativeness}

Representativeness was considered by stakeholders on one hand to be one of the most important attributes for achieving system objectives but on the other as one of the attributes requiring the most improvement. There is a set target for the representativeness of ASPREN data which aligns with the target set in the Australian Influenza Pandemic Plan.\textsuperscript{15} Targets are set to achieve geographical representation however there does not appear to be robust validation of whether this measure of representation is the most appropriate or optimal to use for influenza surveillance. Stakeholders generally agree that ASPREN data should be representative of influenza activity in the community.
However, the system is designed for surveillance of persons who seek primary health care and as such ASPREN data should be representative of persons with ILI who consult a GP.

Against what they thought the target for representativeness should be, stakeholders considered the representativeness of ASPREN syndromic data to be poor (1.3/3). Poor representativeness was the main reason for a lack of confidence in and usability of ASPREN syndromic data. When discussing the objectives of the system with Department of Health epidemiologists, there was a lack of clarity as to whether ASPREN data are required to be representative at a jurisdictional AND national level or only at a national level. Regardless of whether the target measure of representativeness is optimal and whether data should be representative at a jurisdictional level, at a national level, in 2015 ASPREN syndromic data achieved or exceeded target representativeness for metropolitan areas but not for rural or remote areas. In 2015, at a jurisdictional level, target representativeness was not achieved geographically for any state or territory. This was due to poor representation particularly in rural areas but also in remote areas. GP recruitment activities over time have generally improved participation in areas where representation was already achieved. Exceeding target representation is not a useful investment of effort or resources. Perhaps surveillance in rural and remote areas is simply not practical and the desire for representation in these areas not feasible. There may be a political drive to assess the burden of influenza in rural and remote areas however the epidemiological principle behind the inclusion of sentinel sites in these areas is debatable. The low number of sentinel GP participants in rural and remote areas must also be considered in the event of a pandemic where it may be important to draw on a GP network across the country. Furthermore from a week to week basis, consistency in achieving representativeness was poor.

In reports, ASPREN administration does not report against the target measures for representation and an outdated method of classifying remoteness is used. The representativeness of patients selected for laboratory testing versus all ILI patients is good. Although the suggested methods of ILI patient selection for swabbing are not strictly systematic, no major biases in patient selection by GPs were found however there may be a tendency to oversample adults and under-sample children and teenagers. With the Canning Flu Tool upgrade, Indigenous status will be extracted for all ILI patients, provided it is recorded by the GP. Thus, with the upgrade, ASPREN data may be able to assess representativeness by Indigenous status. Using the current targets, for ASPREN data to be representative at a national level, continued data provision from SPNWA is essential. No short or long term threats to continued data provision from SPNWA administrators were identified however changes to funding, for example, may affect the situation. Currently ASPREN is not self-sufficient to achieve national representation.
Timeliness

The third Objective for ASPREN is for it to be an indicator of ILI activity in the community in real time. Stakeholders consider timeliness as one of the most important attributes to achieve system objectives. Stakeholders perceive ASPREN syndromic data to be more timely than virological data (moderate-good (2.4/3) versus moderate (2/3)). There is a lag-time of four to ten days between ILI presentations to a GP and useful data provision to the end-user. This is due to Canning Flu Tool extraction and data download into DMAC occurring once a week and GP consultation estimates being provided once a week. Syndromic and virological data collected from sentinel sites are reported to the Commonwealth on a weekly basis and thus ASPREN surveillance meets the recommendations of the WHO for influenza surveillance standards. Real-time surveillance sounds desirable however it would first need to be determined by stakeholders whether such data would be useful before investing considerable resources to achieve real-time surveillance. Would there be a public health response to a change in ILI rate from one day to the next or would it be considered a temporary aberration? Confidence in the sensitivity and thus the signals generated by ASPREN data need to be improved first before improving timeliness.

Stability

Stability was considered as one of the attributes in most need of improvement but rated second in importance to achieving system objectives. GP involvement in ASPREN appears to be stable and increasing. Stable operation of the Canning Flu Tool and MIS are essential to the stability of the system, particularly if data collection, collation and reporting become more automated. As the sole funding body, continued provision of Commonwealth funding is essential to the stability of ASPREN.

3.9 CONCLUSION

I have found ASPREN to be an important component of influenza surveillance in Australia that fills a gap and adds to our understanding of the epidemiology of influenza infections that require primary care consultation. ASPREN is a valuable system particularly due to the relationship the system administrators maintain with GP members. This allows for appropriate training (e.g. data coding and method of patient selection for sampling) to be given to reporters and also provides a ‘primed’ population of GPs who may be called upon if needed during a pandemic. ASPREN is also valuable as it operates year-round; providing the capacity to detect virus transmission out-of-season.

If ASPREN data were no longer available, there would be a lack of perspective on the clinical severity of the influenza season which may result in inappropriate public messaging. Representative samples
collected through ASPREN are a valuable resource to understand the genetic and antigenic properties of circulating influenza strains. There may be alternative methods to obtain syndromic data from GPs (e.g. methods similar to BEACH\textsuperscript{20} or direct from practice software companies), however the inclusion of laboratory confirmation testing would be more difficult to achieve if a system was devised from scratch.

Currently, there is a lack of confidence in the signals generated by ASPREN syndromic data. Persons responsible for making public health decisions would not activate a public health response using short-term changes in ASPREN data alone. This is mainly due to poor representativeness of GP reporters in non-metropolitan areas which reduces data quality. In the section following, I recommend improvements which I believe would increase the usefulness and acceptability of the system, and provide better quality data with which decisions relating to public health responses may be made. As ASPREN data are not interpreted in isolation, I will also make recommendations as to how ASPREN data may be better incorporated and interpreted considering national influenza surveillance in its entirety.

### 3.10 RECOMMENDATIONS

Based on this evaluation, I recommend that the Commonwealth Department of Health, ASPREN administration, and the National Influenza Surveillance Committee (NISC) consider the following:

<table>
<thead>
<tr>
<th>System-Specific Recommendations</th>
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<tr>
<td><strong>SYSTEM OBJECTIVES</strong></td>
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<tr>
<td>1. Reach a national agreement on the objectives and required outputs of sentinel GP ILI surveillance.</td>
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<tr>
<td><strong>REPRESENTATIVENESS</strong></td>
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<tr>
<td>1. Review methodology for representation targets and determine an evidence-based indicator of representation with consideration to the following:</td>
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<tr>
<td>a. The requirement for data to be representative at a state/territory level.</td>
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<tr>
<td>i. If data are not representative at a jurisdictional level, data should not be reported at this level.</td>
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<tr>
<td>ii. System acceptability and stakeholder involvement may be greater if data are representative at a state/territory level.</td>
</tr>
<tr>
<td>iii. Weighting may be required to adjust data from jurisdictions that are under/over represented in terms of population and/or GP consultation totals.</td>
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</tbody>
</table>
iv. Is it important for locations with less-defined influenza seasons to be represented (e.g. tropical areas)?
b. The requirement for reporting from rural and remote areas.
   i. What is driving the current requirement for geographical representation? Political? Epidemiological? And is geographical representation important to achieve surveillance objectives?
   ii. It may not be practical to include GPs from rural and remote areas as recruitment and maintenance of participation is resource intensive.
   iii. Is it important to have a network of primed GPs across the country in the event of a pandemic response?
   iv. Report against the most current remoteness classification (i.e. the method recommended by the Australian Institute of Health and Welfare).
c. The requirement for surveillance data to be representative by age, sex, Indigenous status, and/or GP workforce characteristics.

2. Maintain target representation from week to week.
   a. Acknowledge the need for a buffer to account for the flux in GP participation due to illness, leave, etc.

3. Ensure the ASPREN system is able to achieve national representation without requiring surveillance data from state/territory administered surveillance systems.

SIMPLICITY

1. Reduce complexity in the ASPREN system:
   a. Remove the collection of data that do not contribute to public health decision making, in line with WHO recommendations.28 This may include the removal of data for conditions other than ILI and the testing of samples for respiratory pathogens other than influenza.
   b. Reduce the amount of manual data collation and cross-checking required by staff. This may be achieved by automating pathology data extraction for selected ILI patients.

SENSITIVITY

1. Reduce uncertainty in the signals generated by ASPREN syndromic and virological data:
   a. Evaluate the usefulness of applying system-specific baselines and thresholds to ILI rates and proportion test positive data.
   b. Collect age-specific (and sex) population denominators for consultation rate and proportion test positive calculations.
REPORTING

1. Improve presentation of ASPREN syndromic and virological data in weekly and annual reports:
   a. Improve transparency of data representativeness. Report against target representativeness in weekly and annual reports.
   b. Present ILI notifications and rates and number of influenza test positive results by age-group in weekly and annual reports. Report standard age groups as recommended by WHO.28
   c. Consider reporting syndromic and virological data by Indigenous status as a minimum in annual reports.
   d. Report characteristics of patients that are selected for swabbing compared with patients presenting with ILI in annual report (e.g. remoteness, sex, age, Indigenous status).

<table>
<thead>
<tr>
<th>Recommendations for National and Jurisdictional Influenza Surveillance</th>
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<tbody>
<tr>
<td>1. Consider the utility of developing and applying baselines and thresholds to each influenza surveillance system.</td>
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<tr>
<td>2. Develop an overall signal (e.g. degree of activity, clinical severity, geographical spread) based on the interpretation of data from all influenza surveillance systems including ASPREN.</td>
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<tr>
<td>3. Develop standardised public health actions taken based if the overall signal ‘triggers’.</td>
</tr>
</tbody>
</table>

3.11 REFERENCES


### 3.12 APPENDICES

**Appendix 3-1 List of stakeholders**

**ASPREN Administration**

- Ms Monique Chilver, Program Manager, The Australian Sentinel Practices Research Network (ASPREN), Discipline of General Practice, School of Population Health and Clinical Practice, The University of Adelaide
- Mr Daniel Blakeley, Administrative Officer, The Australian Sentinel Practices Research Network (ASPREN), Discipline of General Practice, School of Population Health and Clinical Practice, The University of Adelaide
- Ms Tammie-Jane Kalambokas-Ennis, Administrative Officer, The Australian Sentinel Practices Research Network (ASPREN), Discipline of General Practice, School of Population Health and Clinical Practice, The University of Adelaide
- Professor Nigel Stocks, Head of the Discipline of General Practice, Discipline of General Practice, School of Population Health and Clinical Practice, The University of Adelaide

**Commonwealth Influenza Representatives**

- Ms Christina Bareja, Influenza Epidemiologist and Assistant Director, Vaccine Preventable Diseases Surveillance Section, Office of Health Protection, Australian Government Department of Health
• Ms Kate Pennington, Influenza Epidemiologist and Assistant Director, Vaccine Preventable Diseases Surveillance Section, Office of Health Protection, Australian Government Department of Health
• Dr Rachel de Kuyver, Virologist and Influenza Epidemiologist, Vaccine Preventable Diseases Surveillance Section, Office of Health Protection, Australian Government Department of Health
• Ms Rhonda Owen, Former Director, Vaccine Preventable Diseases Surveillance Section, Office of Health Protection, Australian Government Department of Health

**SPNWA Representative**

• Ms Annette Regan, Project Officer, Prevention and Control, Communicable Disease Control Directorate, Western Australia Health

**VicSPIN Representatives**

• Dr James Fielding, Epidemiologist, Epidemiology Unit, Victorian Infectious Diseases Reference Laboratory, The Doherty Institute
• Ms Kristina Grant, Victorian Infectious Diseases Reference Laboratory, The Doherty Institute

**Jurisdictional Representatives**

• Mr David Coleman, Surveillance Coordinator, Communicable Diseases Prevention Unit, Public Health Services, Department of Health and Human Services, Tasmania
• Ms Robin Gilmour, Respiratory Epidemiologist, Communicable Diseases Branch, Health Protection, New South Wales
• Dr Peter Markey, Head of Surveillance, Centre for Disease Control, Department of Health, Northern Territory
• Ms Lesley Scott, Centre for Disease Control, Department of Health, Northern Territory
• Dr Jane Raupach, Medical Epidemiologist, Communicable Disease Control Branch, Department of Health, South Australia
• Ms April Roberts-Witteveen, Epidemiologist, Communicable Disease Control, Health Protection Service, Australian Capital Territory
• Ms Frances Birrell, Advanced Epidemiologist, Epidemiology and Research Unit, Communicable Diseases Branch, Prevention Division, Department of Health, Queensland Government

**WHO CC Representative**

• Dr Sheena Sullivan, Epidemiologist, World Health Organization Collaborating Centre for Reference and Research on Influenza, Australia
OzFoodNet Representative

- Dr Ben Polkinghorne, Coordinating Epidemiologist OzFoodNet, Office of Health Protection, Australian Government Department of Health

Commonwealth Vaccine Preventable Diseases Epidemiologist

- Ms Nicolee Martin, Vaccine Preventable Diseases Surveillance Section, Office of Health Protection, Australian Government Department of Health

Appendix 3-2 Stakeholder survey

Survey administered to influenza epidemiologist(s) in each jurisdiction represented in the ASPREN system, except for Victoria and Western Australia. Survey designed with Survey Monkey: www.surveymonkey.com
ASPREN Evaluation

Welcome to My Survey

As part of an overall evaluation, the aim of this survey is to assess stakeholders’ opinions of the Australian Sentinel Practice Research Network (ASPREN) surveillance system. As a user of ASPREN data, your responses will be invaluable to evaluate how well the system is operating and to better inform recommendations for improvement. The evaluation is endorsed by the National Influenza Surveillance Committee (NISC) and will form part of the requirements for the Master of Applied Epidemiology at ANU.

The survey questions refer to flu activity and how you use ASPREN data within your jurisdiction unless specified otherwise. In the survey, ‘ASPREN data’ refers to both syndromic and virological data unless specified otherwise.

The evaluation follows the CDC framework for evaluating public health surveillance systems. Questions are asked of the usefulness of the system in addition to specific system attributes. Questions on each system attribute are presented on separate pages and attribute definitions from the framework are given on each relevant page under the page heading for your reference.

This questionnaire will take approximately 45 minutes to complete. There are a combination of restricted choices and free text questions. By clicking the previous and next buttons you may move back and forward through the questions and make changes if needed.

If you wish to contact me to clarify any details, please feel free to ring me on 02 62893354 or email me on amy.burroughs@health.gov.au. There is space free on the last page to give any feedback for this questionnaire and also to indicate whether you would like me to follow up this questionnaire with a phone call.

Thank you, your time and input is very much appreciated.
1. Please enter your details

Name
Company
State/Province
Email Address
Phone Number
2. Do you think syndromic surveillance for influenza is important?

Please explain your choice
### ASPREN Evaluation

**Establishing objectives and attributes of the system**

3. From your viewpoint, what are the objectives of ASPREN?

4. Do you think ASPREN is achieving these objectives?

5. In your opinion, firstly indicate the 3 most important attributes required to achieve the objectives of ASPREN. Secondly, please indicate the 3 attributes of the system that require the most improvement.

<table>
<thead>
<tr>
<th>Most Important</th>
<th>Needs Improvement</th>
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<tbody>
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<td>Simplicity</td>
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<td>Stability</td>
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   - Email
   - Fax
   - Post
   - Database access
   - Other (please specify)

   - Daily
   - Weekly
   - Fortnightly
   - Monthly
   - Other (please specify)

8. What data are presented to you? Multiple answers possible.
   - Line-listed
   - Aggregated
   - State-specific
   - National summary
   - Syndromic - influenza-like illness (ILI)
   - Syndromic - other conditions (e.g. shingles, chickenpox, pertussis, gastroenteritis)
   - Virological - influenza positives
   - Virological - influenza subtypes
   - Virological - other respiratory pathogens
   - Other (please specify)
9. In what format are ASPREN data presented to you? Multiple answers possible.

☐ Graph
☐ Table
☐ Descriptive interpretation
☐ Line-list
☐ Other (please specify)
Performance of the system: Usefulness

Usefulness: A surveillance system is useful if it contributes to the prevention and control of adverse health-related events, including an improved understanding of the public health implications of such events.

10. In your opinion, please indicate the degree of usefulness of ASPREN syndromic data.

- Poor
- Moderate
- Good
- N/A

11. In your opinion, please indicate the degree of usefulness of ASPREN virological data.

- Poor
- Moderate
- Good
- N/A

12. Are ASPREN data presented to you in a way that you find useful?

- Yes
- No

13. Could the presentation of ASPREN data be improved to increase its usefulness to you?

- Yes
- No

If yes, please suggest improvements:

If yes, please suggest improvements:

14. Indicate the type(s) of ASPREN data you use. Multiple answers possible.

- Syndromic data - influenza-like illnesses (ILI)
- Syndromic data - other conditions
- Virological data - influenza positives
- Virological data - influenza subtypes
- Virological data - other respiratory pathogens
15. How are ASPREN data used in your work?


16. Do you use ASPREN data only within the flu season or all year round?


17. How many members of your team use ASPREN data?


18. Do you disseminate ASPREN data to other persons outside of your team?

If yes, for what use?


19. If known, do other members of your team use data of other conditions collected by ASPREN? (e.g. shingles, chickenpox, gastroenteritis)

If yes, how? If no, why not?


20. If known, how were ASPREN data used during the 2009 pandemic? Was this information useful?


21. Do you think there are other potential untapped uses for the data already collected by ASPREN?

If yes, for what use(s)?

22. Do you think there are other potential untapped uses of the ASPREN system?

If yes, please describe
ASPREN Evaluation

Performance of the system: Simplicity

_Simplicity: Refers to both the structure of the system and ease of operation. Surveillance systems should be as simple as possible while still meeting their objectives._

23. In your opinion, indicate the degree of simplicity of ASPREN syndromic data.

<table>
<thead>
<tr>
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24. In your opinion, indicate the degree of simplicity of ASPREN virological data.

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25. Is a significant amount of time required for you to interpret ASPREN data?

If yes, please explain why

26. Is a significant amount of time required for you to incorporate ASPREN data into your work?

If yes, please explain why
**ASPREN Evaluation**

**Performance of the system: Data quality**

*Data quality: Reflects the completeness and validity of the data recorded in the system.*

27. In your opinion, indicate the degree of quality of ASPREN syndromic data.

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If poor, please explain your answer

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28. In your opinion, indicate the degree of quality of ASPREN virological data.

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If poor, please explain your answer
ASPREN Evaluation

Performance of the system: Representativeness

Representativeness: A public health system that is representative accurately describes the occurrence of a health-related event over time and its distribution in the population by place and person.

29. What should ASPREN syndromic data be representative of?

   

30. Do you use methods to measure representativeness of ASPREN syndromic data?

   

31. In your opinion, indicate the degree of representativeness of ASPREN syndromic data.

   Poor  Moderate  Good

   

If poor, please explain your answer

   

ASPREN Evaluation

Performance of the system: Flexibility

*Flexibility: A flexible surveillance system can adapt to changing information needs or operating conditions with little additional time, personnel, or allocated funds. Flexible systems can accommodate, for example, new health-related events, changes in case definitions or technology, and variations in funding or reporting sources. In addition, systems that use standard data formats can be easily integrated with other systems.*

32. In your opinion, indicate the degree of flexibility of the ASPREN system.

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If poor, please explain answer
**ASPREN Evaluation**

Performance of the system: Sensitivity

*Sensitivity: The sensitivity of a surveillance system can be considered on two levels. First, at the level of case reporting, sensitivity refers to the proportion of cases of a disease detected by the surveillance system. Second, sensitivity can refer to the ability to detect outbreaks, including the ability to monitor changes in the number of cases over time.*

33. In your opinion, please indicate the degree of sensitivity of the ASPREN syndromic surveillance system.

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34. For influenza surveillance, at what level are you assessing trends in your work? Multiple answers possible.

- [ ] Individuals
- [ ] Community
- [ ] State/Territory
- [ ] National

Other (please specify)

35. Is there evidence to demonstrate that the sensitivity of ASPREN data are adequate at this level?

If yes, please describe
ASPREN Evaluation

Performance of the system: Timeliness

Timeliness: Reflects the speed between steps in a system.

36. In your opinion, indicate the degree of timeliness of ASPREN syndromic data.

- Poor
- Moderate
- Good

37. In your opinion, indicate the degree of timeliness of ASPREN virological data.

- Poor
- Moderate
- Good

38. Are ASPREN data delivered to you in a time frame that allows you to usefully incorporate the information into your work?

- Yes
- No

If no, please suggest improvements to timeliness:

[Blank space for comments]
ASPREN Evaluation

Performance of the system: Stability

**Stability:** Refers to the reliability (i.e., the ability to collect, manage, and provide data properly without failure) and availability (the ability to be operational when it is needed) of the system.

39. In your opinion, indicate the degree of stability of the ASPREN system.

<table>
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If poor, please explain answer

[Blank space for answer]
ASPREN Evaluation

ASPREN as a component of national influenza surveillance

40. Please explain how ASPREN data contribute to your decision making.

41. Do ASPREN data contribute to decision making on their own or in combination with other surveillance systems?

42. Please explain how ASPREN data contribute to the prevention and control of influenza.

43. Do ASPREN data contribute to the prevention and control of influenza on their own or in combination with other surveillance systems?

44. Do you have confidence in the signals generated by ASPREN data?

If no, why not?
45. Do the signals generated by ASPREN data generally agree with other influenza surveillance systems?

46. If there is disagreement between ASPREN data and other surveillance systems, how do you interpret this?

47. Do you think ASPREN data complement, fill gaps or overlap that of other influenza surveillance systems? Multiple answers possible.
- [ ] Complement
- [ ] Fill gaps
- [ ] Overlap

Please elaborate on your answer

48. If ASPREN data were no longer available to you, how would this affect your work?
49. Please use this space to provide any further comments or feedback on this questionnaire.

50. Would you like to be contacted by phone to further discuss this questionnaire?

If yes, please provide contact phone number: 
CHAPTER 4   EPIDEMIOLOGICAL PROJECT: USE OF HOSPITAL SERVICES BY INDIVIDUALS NOTIFIED WITH COMMUNITY-ASSOCIATED METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS (CA-MRSA), KIMBERLEY, WESTERN AUSTRALIA

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Appendix 4-3. Procedures of interest to CA-MRSA infections and classifying ACHI code .......... 141
4.1 ROLE

I was offered the opportunity to join this project by Dr Paul Armstrong, Director of the Communicable Disease Control Directorate (CDDC) at the Western Australia Department of Health (WA DoH). Ms Simone Tempone (WA DoH) had conducted an unpublished review of separation data for *S. aureus* positive patients who presented to hospitals in the Kimberley region. This analysis showed an increasing burden on the hospital system due to patients with MRSA requiring overnight hospital admission and highlighted the need for data linkage with CA-MRSA notifications and emergency presentations in the region. Dr Anna Beswick, a public health medicine registrar at the WA DoH had developed the study design and sought initial ethics approval from the WA DoH Human Research Ethics Committee (HREC), Western Australian Aboriginal Health Ethics Committee (WAAHEC), Kimberley Aboriginal Health Planning Forum Research Subcommittee and data linkage from the WA DoH Data Linkage Branch for the period 1 July 2003 to 30 June 2013. Due to the time frames involved in receiving linked data, Dr Beswick was not available to perform the data analysis and descriptive write up of the project as she had moved to another training position. Dr Armstrong approached Associate Professor Martyn Kirk to ask whether an MAE scholar would be available to analyse the data.

My role in the project was to seek an amendment to the WA DoH HREC (add myself as an investigator and the Australian Government Department of Health as a secondary study site) and request an update to the data extraction and linkage to extend the study period to 30 June 2015. Dr Armstrong and Dr Beswick provided greatly needed assistance with getting ethics approval and linkage performed. This project was designed as a descriptive study which would then lead to future analytical projects such as a case-control study and economic analyses. Dr Beswick provided me with a data analysis plan which I amended based on the amount of time I had available to complete the project and on the objectives of the project that were finalised after discussions with Dr Beswick. I first received the data from the early data request (up until 30 June 2013) which allowed me to set up Stata coding to clean, merge and analyse the data before the updated set was provided. Mikhalina Dombrovskaya and Alexandra Godfrey from the WA DoH Data Linkage Branch assisted me with any questions I had regarding the data linkage process.

A CA-MRSA steering group was set up to have input into project design, review project results and to provide input into the preparation of a manuscript for publication. For this steering group I took the lead to organise meetings, prepare agenda papers and record and circulate meeting minutes. To date, three steering group meetings have occurred. Apart from me, Dr Armstrong, Ms Simone Tempone and Dr Beswick, the steering group membership consisted of healthcare-associated infection specialists,
clinicians and epidemiologists from a variety of WA departments and organisations. Members included Professor Geoffrey Coombs (Murdoch University/PathWest), Ms Ashley Eastwood (Kimberley Population Health Unit, WA DoH), Ms Rebecca McCann (WA DoH), Ms Allison Peterson (WA DoH), Dr Asha Bowen (Princess Margaret Hospital for Children and Telethon Kids Institute), Professor David Atkinson (Rural Clinical School of WA), Dr Michael Leung (Pathwest), and Mr Martin Cutter (Kimberley Aboriginal Medical Services). To date, the steering group have provided invaluable input into the analysis methodology and the interpretation of results.

4.2 LESSONS LEARNT

This project was my first introduction to handling and analysing large linked datasets. Initially I thought ‘linked’ meant that all the data would be in one file with all records in the form of a line list per individual. However, each dataset (notifications, inpatient and emergency records) was provided in separate files and the ‘linked’ component was a unique identifier for individuals and for records. My skills using Stata have improved immensely after completing this project. In order to merge datasets and select certain records based on time-periods from collection date, I have had to become familiar with loop commands and changing data arrangement from wide to long and vice versa. Ms Simone Tempone introduced me to Tableau Software which has been very useful in creating visually attractive figures.

The most challenging aspect of this project was deciding on definitions for hospital and emergency records associated with a notification of CA-MRSA. Initially I examined the data to look at hospital and emergency records that occurred 0, 3 and 6 months pre or post a positive notification. It was very useful to be able to talk to clinicians in the steering group meeting to determine what made clinical sense. It was decided to only select hospital and emergency records during which the positive sample was collected. This was to increase the specificity of our analysis but at the expense of sensitivity. I also had to become familiar with hospital coding and the definitions of admissions, separations and episodes of care. Ms Tempone was a great source of help in unravelling the complexities of hospital records. It was also challenging for me to decide upon diagnoses of interest for CA-MRSA infections, procedures of interest and risk factors of interest. Information in the literature guided these selections however the real challenge came when having to select ICD-10-AM and ACHI codes for these diagnoses as literature for this was lacking. Again, it was very helpful to be able to present my proposals to people who have relevant clinical and laboratory experience in order to decide on definitions and codes that are clinically relevant.
4.3 PUBLIC HEALTH IMPLICATIONS

To the best of my knowledge, this is the first published report of age-standardised notification rates of CA-MRSA by Indigenous status for the Kimberley. This project highlights the very high notification rates for Aboriginal and Torres Strait Islander persons, with 1 in 10 of the Aboriginal and Torres Strait Islander population having a notification of CA-MRSA in 2015. As high infection prevalence has been linked to remoteness, social disadvantage and sanitary living conditions, there is obviously a need to improve fundamental determinants of health to reduce community CA-MRSA prevalence. This project shows that an increasing overall burden on hospital services, particularly emergency departments, would be expected if infections with CA-MRSA continue to increase in the region. The increasing proportion of notifications of Micro-Alert B, PVL positive clones does not appear to be associated with increasing clinical severity of infections which highlights the importance of not overemphasising the virulence of BPVL+ isolates in screening programmes; all isolates should be regarded as capable of causing severe disease. The results of this project will be presented to the steering group for their use and will also be published as a scientific manuscript.

4.4 ABSTRACT

Objectives: To describe the frequency and characteristics of admitted episodes of care and emergency department presentations associated with notifications of CA-MRSA for residents of the Kimberley region of Western Australia and to determine whether the clinical severity of CA-MRSA associated disease is changing over time and by isolate Panton-Valentine leucocidin (PVL) status.

Design, setting and participants: A retrospective descriptive study of 4,484 Kimberley residents with 5,483 notifications of CA-MRSA where the sample was collected between 1 July 2003 and 30 June 2015. These individuals were linked to state admitted episode of care and emergency department presentation records. Admitted episodes of care and emergency presentations during which a positive specimen was collected were selected and analysed for outcome measures.

Main outcome measures: The number of admitted episodes of care and emergency presentations associated with a detection of CA-MRSA, as total number and per person as a proportion of the number of individuals notified with CA-MRSA. Clinical severity of infection was assessed by measuring mean length of stay, related diagnoses and reasons for admission and the number of related surgical procedures.

Results: The total number of associated admitted episodes of care and emergency presentations over the study period was 1,284 and 2,041, respectively. The proportion of persons whose detection of CA-MRSA was made during an admitted episode of care significantly decreased over time for those
notified with Micro-Alert B, PVL-positive (BPVL+) and Micro-Alert B, PVL-negative (BPVL-) clones ($p<0.001$ for both). The proportion of persons whose detection of CA-MRSA was made during an emergency presentation significantly increased with time for those notified with BPVL- clones ($p<0.001$). The mean length of stay for associated admitted episodes of care was significantly lower for BPVL+ clones (4.8 days, 95% CI: 4.2-5.4) compared to BPVL- clones (10.9 days, 95% CI: 7.8-14.0) ($p<0.001$). No significant trend was observed in the average length of stay over time for admitted episodes of care associated with BPVL+ and BPVL- clones ($p=0.16$, $p=0.05$, respectively). The majority (63%) of admitted episodes of care were associated with patients presenting with skin and soft tissue infections (abscess, cellulitis or impetigo) and the invasive to non-invasive infection ratio for BPVL+ clones was lower than for BPVL- clones ($p<0.001$). Of persons with skin and soft tissue infections, for BPVL+ clones, 1 in 2 underwent surgical intervention (aspiration, incision, excision or drainage) and for BPVL- clones, 1 in 3 underwent a surgical intervention.

**Conclusions:** The increasing number of persons notified with CA-MRSA in the Kimberley region is associated with an increasing number of associated admitted episodes of care and emergency presentations for state-wide healthcare providers. Overall the results of this study show that per person, the use of hospital services is not significantly increasing with time for those notified with CA-MRSA however, emergency departments do see a large proportion of patients and may be an important first port of call for diagnosis and initiation of clinical management. Overall the results of this study do not indicate that isolates with PVL genes cause more severe clinical disease. Due to the dynamic epidemiology of CA-MRSA infections it will be important in the future to continue clinical and molecular surveillance to detect changes in virulence and environmental niches of these pathogens.

**4.5 INTRODUCTION**

The World Health Organization considers antimicrobial resistance as a serious emerging threat to global public health. Persons infected with resistant organisms generally have a higher risk of adverse clinical outcomes including death, and consume more healthcare resources compared to those infected with susceptible organisms. *Staphylococcus aureus* is the most commonly isolated bacterial pathogen in humans and is an important cause of skin and soft-tissue infections, pneumonia, septic arthritis, endocarditis, osteomyelitis, foreign-body infections, and sepsis. Methicillin-resistant *S. aureus* (MRSA) isolates are resistant to penicillins and other β-lactam antibiotics and in the past were confined mainly to health care environments and referred to as health-care associated MRSA (HA-MRSA). However, over the last 20 years there has been an increase in the number of MRSA infections in persons without the usual risk factors for HA-MRSA acquisition and an increased recognition of new MRSA clones, called community-associated MRSA (CA-MRSA) responsible for such infections.
As both CA-MRSA and HA-MRSA clones now circulate in the community and CA-MRSA clones are more frequently being isolated from nosocomial-acquired infections, it may be difficult to classify CA-MRSA and HA-MRSA clones based solely on a patient’s lack of healthcare risk factors.\textsuperscript{3} Where available, molecular methods are considered a more accurate means of identifying and classifying CA-MRSA clones. Community-associated MRSA clones may be differentiated from HA-MRSA clones by genotypic features such as relatively smaller staphylococcal chromosomal cassette \textit{mec} (\textit{SCCmec}) elements and frequently the presence of a mobile virulence factor, the Panton-Valentine leucocidin (PVL) genes.\textsuperscript{2} Phenotypically, CA-MRSA clones are generally resistant to fewer non-β-lactam antibiotics compared to HA-MRSA clones.\textsuperscript{2} Clinically, CA-MRSA infections generally occur in younger, otherwise healthy patients and are associated predominantly with skin and soft-tissue infections but may also cause severe clinical syndromes such as necrotizing pneumonia and severe sepsis.\textsuperscript{2} The protein coded by PVL genes mediates leukocyte and tissue destruction and its presence is generally thought to cause more severe disease than PVL negative isolates.\textsuperscript{2,4}

In Australia, CA-MRSA infections first emerged in Western Australia (WA) in the early 1990s, mainly associated with Aboriginal and Torres Strait Islander people in remote communities, and the clones were called WA-MRSA.\textsuperscript{5} Since this time, a number of studies have noted a heavy burden of staphylococcal disease and an increasing prevalence of CA-MRSA in Aboriginal and Torres Strait Islander populations across northern Australia.\textsuperscript{6,7} Furthermore, studies have indicated that Aboriginal and Torres Strait Islander persons infected with CA-MRSA are more likely to develop severe clinical manifestations compared to non-Indigenous persons.\textsuperscript{8,9} On the east coast, CA-MRSA infections were first observed in the mid-1990s where novel clones were identified including sequence type 30 (ST30) South-West Pacific (SWP) clone and ST93-IV Queensland clone associated with persons of Polynesian and European background, respectively.\textsuperscript{10,11} Facilitated by local and international travel, a number of CA-MRSA clones presently circulate throughout Australia. A number of overseas CA-MRSA clones have been isolated in Australia including ST8-IV (USA300, PVL positive), ST59-V (Taiwan CA-MRSA, PVL positive), and ST772-V (Bengal Bay clone, PVL positive).\textsuperscript{12} Since 2008, the most common CA-MRSA clone in Australia is the ST93-IV Queensland clone which is PVL positive; contributing to the increasing proportion of CA-MRSA isolates in Australia that contain the PVL genes.\textsuperscript{13}

In Western Australia, notification rates of CA-MRSA in the Kimberley are increasing more rapidly than in any other region in the state.\textsuperscript{14} For example, in the Kimberley, the number of CA-MRSA clones increased sixteen-fold from 2003/2004 to 2014/2015 compared to a three-fold increase for the state overall.\textsuperscript{14} In 2014/2015, PVL-positive CA-MRSA clones outnumbered PVL-negative clones 3:1 in the
Kimberley. The 2014 estimated resident population of the Kimberley was 39,099 persons over a land area of nearly 42 million hectares; giving a low population density. Almost all of the Kimberley health region is classified as Very Remote according to the Australian Standard Geographical Classification Remoteness Area Structure. At the 2011 census, Aboriginal and Torres Strait Islander people comprised 40% of the Kimberley population.

4.5.1 Study objectives
Given the rapidly increasing notification rates of CA-MRSA in the Kimberley region, including an increased proportion of potentially more virulent PVL positive isolates, the objectives of this study are to:

1. Describe the epidemiology of CA-MRSA notifications in the Kimberley for the period 1 July 2003 to 30 June 2015 by clone PVL status and demographic factors of the individual (Indigenous status, age and sex).
2. Describe the frequency of admitted episodes of care, related procedures, and emergency department presentations for persons notified with CA-MRSA.
3. Assess the clinical severity of CA-MRSA infections through the analysis of severity indicators (proportion of persons with an isolate requiring admission to hospital, related procedures or emergency care, average length of stay in hospital, the invasive to non-invasive ratio for selected diagnoses and the proportion of emergency presentations that are admitted to hospital).
4. Assess whether the frequency and clinical severity of health-care use changes with time and/or by clone PVL status.

4.6 METHODS

4.6.1 Study type
This study is a descriptive analysis of notifications of CA-MRSA from Kimberley residents where a positive sample was collected between 1 July 2003 and 30 June 2015 paired with a descriptive analysis of admitted episodes of care and emergency department data linked to those individuals.

4.6.2 Data sources

4.6.2.1 Notification data
Notification data were obtained from the Australian Collaborating Centre for Enterococcus and Staphylococcus Species (ACCESS) Typing and Research and provided by the Communicable Disease Control Directorate. Notification data were extracted with the following inclusion criteria: persons
with a Kimberley address at the time a sample was collected between 1 July 2003 and 30 June 2015 where the sample was positive for a CA-MRSA clone identified by ACCESS.

Colonisation or infection with MRSA has been a notifiable condition in WA since 1982 and since 1997 all MRSA isolates have been referred to ACCESS where isolates are characterised as either HA-MRSA or CA-MRSA based on molecular markers.  

4.6.2.2 Linkage

Persons notified with CA-MRSA over the study period were linked to admitted episode of care and emergency department data by WA Department of Health Data Linkage Branch using probabilistic linkage methods. The index date was the CA-MRSA sample collection date. Admitted episodes of care and emergency department data were extracted for the period six months before the index date to the most recent record available. Across ACCESS, admitted episodes of care and emergency department records, individuals are coded with a unique project-specific identification number.

4.6.2.3 Admitted episodes of care

Admitted episodes of care data were obtained from the Government of WA Department of Health Hospital Morbidity Data Collection (HMDC) and provided by WA Department of Health Data Linkage Branch. These data excluded boarders, healthy newborns, organ procurements, aged care residents and funding hospital (duplicate) cases. The HMDC includes all admitted episodes of care that occur in the following Western Australian health services:

- Public acute hospitals
- Public psychiatric hospitals
- Private acute hospitals (licensed by WA Health)
- Private psychiatric hospitals (licensed by WA Health)
- Private day surgeries (licensed by WA Health)

Admitted episodes of care were classified as period from a formal admission to a formal separation, counted in days.

4.6.2.4 Emergency Department data

Emergency department data were obtained from the Government of WA Department of Health Emergency Department Data Collection (EDDC) and provided by WA Department of Health Data Linkage Branch. The EDDC contains data on emergency department activity in WA’s public hospitals, as well emergency department activity from private hospitals under contract with the WA Government.
4.6.2.5 Population data
Population data over the 2003-2015 period for the Kimberley region were obtained from EpiCalc at the WA Department of Health. EpiCalc does take into account the underreporting of Aboriginal people as determined by the ABS; the data were updated in 2012 and also again in 2013 and 2016 with the introduction of the East Metro Health Service. 2015 population data is a projected population determined from data from the previous 10 years using linear regression.

4.6.3 Definitions and measurements

4.6.3.1 Indigenous status
Indigenous status of individuals was recorded as “Indigenous” or “non-Indigenous.” “Indigenous” refers to Aboriginal and Torres Strait Islander persons. Indigenous status was provided by the WA Data Linkage branch and was determined for each individual using a validated algorithm to derive a consensus status across one or multiple data records held in one or multiple WA government administrative data sets.

4.6.3.2 Sex
A consensus sex record was created for each individual using all records of sex across all data sources (ACCESS notifications, admitted episode of care and emergency department data). The consensus sex was the sex that appeared in 2/3 or more of all records. For those individuals in the ACCESS dataset that were not linked to another dataset, a consensus was determined using notification records only.

4.6.3.3 Micro-Alert category, PVL status and ST
Isolates were classified into one of three categories:

- Micro-Alert C CA-MRSA
- Micro-Alert B CA-MRSA (PVL positive)
- Micro-Alert B CA-MRSA (PVL negative)

Micro-Alert C CA-MRSA clones have increased virulence or transmissibility of antimicrobial resistance as determined by the WA Multi-Resistant Organism Expert Advisory Group. Appendix 4-1 shows isolates notified over the study period categorised by clone name, Micro-Alert Category, PVL status and international sequence type nomenclature (ST).

Prior to 1 July 2014, clone identification data were available for Micro-Alert B, PVL negative isolates (e.g. WA 1, WA 2). From 1 July 2014, Micro-Alert B, PVL negative isolates are no longer identified by clone type and are instead grouped and reported by the Micro-Alert Category.
4.6.3.4 Diagnoses and risk factors of interest to CA-MRSA infections
Principal and additional diagnoses recorded for admitted episodes of care related to a CA-MRSA notification were assessed for their relevance to CA-MRSA infection. Codes were interpreted using The International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification (ICD-10-AM). Appendix 4-2 shows the diagnoses (impetigo, abscess, cellulitis, arthritis, osteomyelitis, sepsis, endocarditis, pneumonia and urinary tract infection) and risk factors of interest to this study and the ICD-10-AM codes used to classify them.

4.6.3.5 Invasive/non-invasive infections
Invasive CA-MRSA infections are considered those with a diagnosis of interest of arthritis, osteomyelitis, sepsis and endocarditis (infection of a normally sterile site). Non-invasive CA-MRSA infections are considered those with a diagnosis of interest of impetigo, abscess, cellulitis, urinary tract infection and pneumonia.

4.6.3.6 Procedures of interest to CA-MRSA infections
Admitted episodes of care associated with a CA-MRSA notification where the principal or additional diagnoses coded for skin or soft tissue infection (abscess, cellulitis or impetigo) were assessed for procedures that occurred during that episode of care. Any principal and additional procedures recorded were assessed for their relevance to CA-MRSA infection. Codes were interpreted using the Australian Classification of Health Interventions (ACHI) procedure codes. Appendix 4-3 shows the procedures, ACHI classifying codes and the procedure categories considered relevant to CA-MRSA infection (aspiration, incision, excision or drainage).

4.6.3.7 Associated admitted episode of care, “associated episode”
An admitted episode of care during which a positive detection of CA-MRSA was made is referred to as an associated episode. Associated episodes are analysed further for recorded diagnosis codes, length of stay and procedure codes.

4.6.3.8 Associated emergency department presentation, “associated presentation”
An emergency department presentation is referred to as an associated presentation if a positive detection of CA-MRSA is made on the same day as the emergency presentation.

4.6.3.9 Admission to hospital from emergency department
For associated presentations, records where a ‘1 : Admitted to ward/other admitted patient unit’ was recorded in the ‘Disposal Code’ field were considered associated presentations where the patient was admitted to hospital.
4.6.3.10 Emergency presentations due to skin-related disease
For associated presentations, records where a ‘9: Diseases and disorders of the skin, subcutaneous tissue and breast’ was recorded in the ‘Major Diagnostic Category’ (MDC) field were considered associated presentations due to skin-related disease. The MDC field was 99% complete for the complete dataset.

4.6.4 Exclusions

4.6.4.1 Screening tests
Any isolate collected for screening purposes was excluded from the ACCESS dataset [374 exclusions].

4.6.4.2 Duplicate isolate
A duplicate CA-MRSA isolate was considered an isolate with an identical phenotype (antibiogram) to an isolate received from the same patient within the previous 12 months. Duplicate records were removed from the analysis and were not linked to hospital admission or emergency presentation data [814 exclusions].

4.6.4.3 HA-MRSA
Notifications of HA-MRSA clones were excluded from analysis [99 exclusions].

4.6.4.4 Untyped isolates
Isolates where clone information was not available were excluded from analysis [4 exclusions].

4.6.4.5 Postcodes
Notifications of CA-MRSA with postcodes for Christmas Island and Cocos Islands were excluded [41 exclusions]. Notifications from the following postcodes were excluded as they did not map to any known location: 6775 [5 exclusions], 6766 [1], 6763 [1], 6747 [2], 6745 [1], 6734 [2], 6729 [1], 6727 [1], 6719 [1], and 6717 [1]. In some instances an individual with multiple notifications was recorded with multiple postcodes. For the same individual, where a meaningless postcode was linked to another notification recorded with a meaningful postcode, assuming that individual resided in the same location over the study period, the meaningful postcode was taken as place of residence for that individual [3 changes].

4.6.4.6 Admissions for extracorporeal dialysis, chemotherapy or radiotherapy
Of the complete admitted episode of care dataset, records were removed from further analysis if the principal diagnosis coded for extracorporeal dialysis [Z49.1], chemotherapy [Z51.1] or radiotherapy [Z51.0] and if the additional diagnosis fields did not code for any one of the diagnoses of interest to
CA-MRSA infections [47,126 records for dialysis (71% of complete dataset) & 79 records for chemotherapy excluded]. No records were coded for radiotherapy. Dialysis admissions comprised the majority of records in the dataset and were excluded as they represented ongoing and regular visits that were primarily for a condition unrelated to CA-MRSA infection.

4.6.5 Outcome factors
Notification data are presented as age-specific and age-standardised notification rates of CA-MRSA. Admitted episode of care data are presented as number of associated episodes, number and category of diagnoses of interest, and number of procedures of interest. Associated episodes and presentations are presented per person, as a proportion of all individuals notified with CA-MRSA. Outcome factors were stratified by year and isolate Micro-Alert category/PVL status.

As an indication of clinical severity over time, for associated episodes, results are presented as mean length of stay and the proportion of all notifications of CA-MRSA that are detected during an admitted episode of care. For associated presentations, results are presented as the proportion of associated presentations that result in an admission to hospital and the proportion of associated presentations that are due to skin-related disease.

As an indication of clinical severity by PVL status, for associated episodes, overall mean length of stay and the total proportion of CA-MRSA notifications detected during an admitted episode of care are compared between BPVL+ and BPVL- clones. For associated presentations, the total proportion of CA-MRSA notifications detected at emergency presentation, the total proportion of associated presentations that result in an admission to hospital and the total proportion of associated presentations due to skin-related disease are compared between BPVL+ and BPVL- clones.

4.6.6 Data management
Data were managed and analysed using Microsoft Excel 2010, Epi Info and Stata version 13. Figures were produced using Tableau Software (www.tableau.com).

4.6.7 Statistical analysis
Age-standardised rates per 100,000 population were calculated using the direct method. As CA-MRSA notification data were analysed for half of 2013 and half of 2015, rates were calculated for these years by multiplying calculated rates by two. Poisson regression was used to determine the significance of increases in age-standardised rates between years. A Mann-Whitney test was used to compare differences in non-parametric continuous data. A Kruskal-Wallis test for trend was used to assess significance for continuous data across ordered groups. A chi-squared test was used to assess
significant differences for categorical data and the Stata ptrend command was used to assess the significance of trends in proportions across ordered groups. Point estimates are presented with 95% confidence intervals. $P < 0.05$ is considered a statistically significant association.

4.6.8 Ethics approval
Ethics approval was obtained from the Government of Western Australia Department of Health Human Research Ethics Committee, the Western Australian Aboriginal Health Ethics Committee (WAAHEC) and the Kimberley Aboriginal Health Planning Forum Research Subcommittee.

4.7 RESULTS

4.7.1 Notifications of CA-MRSA in the Kimberley
From 1 July 2003 to 30 June 2015, there were 5,483 notifications of CA-MRSA. The lowest number of notifications occurred in the 2003/04 fiscal year (64 notifications) and the highest number occurred in 2014/15 (1,594 notifications). By Indigenous status, 4,795 (87%) notifications were for Aboriginal and Torres Strait Islander persons, 659 (12%) for non-Indigenous persons, and 29 (1%) notifications were of unknown Indigenous status. By sex, 2,896 (53%) notifications were for females, 2,577 (47%) for males, and 10 notifications had no sex recorded (<1%). By individual, 4,484 persons were notified with at least one isolate of CA-MRSA, with a range of 1-8 notifications per person over the time period. The median number of notifications per person did not change over time and remained at 1 notification per person per year.

The highest proportion of notifications was Micro-Alert B, PVL positive clones (BPVL+) (3,462 notifications, 63%). Micro-Alert B, PVL positive clones exceeded 50% of yearly notifications from 2011/12 onwards; before this time the majority of notifications were for Micro-Alert B, PVL negative clones (BPVL-). The Queensland clone (ST93-IV [2B]) accounted for 43% of all notifications and 69% (2,382/3,462) of BPVL+ clones, with notifications for this clone increasing by a factor of 162 from 2004/05 to 2014/15 (5 to 811 notifications). No notifications of BPVL+ occurred in 2003/04. Clone WA 121 (ST5-IV [2B]) accounted for 910 notifications and increased by a factor of 436 from 2010/11 to 2014/15 (<5 to >400 notifications). From 2003/04 to 2013/14 where clone type data are available for BPVL- isolates, WA 1 clone (ST1-IV [2B]) accounted for 27% (1,050/3,889) of all isolates and 63% (1,050/1,676) of BPVL- clones. Numbers of BPVL- clones also increased across the time period (lowest yearly number of notifications in 2003/04 (64) and highest number in 2014/15 (335)) but not as rapidly as the BPVL+ clones. Over the study period there were 10 notifications of Micro-Alert C clones. These notifications occurred from 2010/11 to 2014/15.
Figure 4-1 shows the number of notifications of CA-MRSA across the study period by Micro-Alert category/PVL status, stratified by Indigenous status. This figure shows the overall large proportion of notifications for Aboriginal and Torres Strait Islander persons and the increasing proportion of BPVL+ clones with time. The ratio of notifications for Aboriginal and Torres Strait Islander persons to non-Indigenous persons increased from 5:1 in 2003/04 to 11:1 in 2014/15.

Figure 4-1. Number of notifications of CA-MRSA by Indigenous status, Micro-Alert Category/PVL status, year (2003/04 to 2015/15)

Figure 4-2 shows age-standardised notification rates by Indigenous status over the study period. Rates for Aboriginal and Torres Strait Islander persons exceeded those for non-Indigenous persons across the entire period and from 2008, rates for Aboriginal and Torres Strait Islander persons increased rapidly. From 2013 to 2015, rates for Aboriginal and Torres Strait Islander females and males significantly increased by 131% and 103%, respectively (\(p<0.001\) for both). Rates for non-Indigenous persons also increased over the study period, with rates significantly increasing by 65% and 90% from 2014 to 2015 for females and males, respectively (\(p<0.001\) for both).
The median age of notifications for Aboriginal and Torres Strait Islander persons and non-Indigenous persons was 24.0 and 38.5 years, respectively. The median age of notifications for Micro-Alert C, BPVL+ and BPVL- clones was 34.9, 22.2 and 31.7 years, respectively. Figure 4-3 shows notification rates of CA-MRSA over the study period by age-group and Indigenous status. For Aboriginal and Torres Strait Islander persons, high rates are observed for 0-9 year olds and persons over 80 years. For non-Indigenous persons, the highest rates occur for persons over 70 years. The highest rate ratios for Aboriginal and Torres Strait Islander persons compared to non-Indigenous persons occurred for the 40-49 year age group (13:1).
Figure 4-3. Notification rate of CA-MRSA by age-group and Indigenous status, 1 July 2003 to 30 June 2015

Measure Names
- Min. Indigenous
- Min. non-Indigenous
4.7.2 Admitted episodes of care data

4.7.2.1 Associated episodes

In total there were 1,285 admitted episodes of care during which at least one notification of CA-MRSA was made. For BPVL+ clones, 699 admitted episodes of care were associated with at least one notification. Of these, the top two principal reasons for admission fell under the ICD-10-AM chapters of ‘Diseases of the skin and subcutaneous tissue’ (384 associated episodes, 55%) and ‘Injury, poisoning and certain other consequences of external cause’ (129 associated episodes, 18%). Of the chapter ‘Injury, poisoning and certain other consequences of external cause,’ 28 associated episodes (22%) were coded as injuries to the wrist and hand, 20 (16%) as injuries to the ankle and foot, and 19 (15%) as complications of surgical and medical care.

For BPVL- clones, 585 admitted episodes of care were associated with at least one notification. Of these, the top two principal reasons for admission fell under the chapters of ‘Injury, poisoning and certain other consequences of external cause’ (161 associated episodes, 28%) and ‘Diseases of the skin and subcutaneous tissue’ (142 associated episodes, 24%). Of the chapter ‘Injury, poisoning and certain other consequences of external cause,’ 27 associated episodes (18%) were coded as complications of surgical and medical care, 25 (16%) as injuries to the wrist and hand, and 25 (16%) as injuries to the knee and lower leg.

The average age of persons with admitted episodes of care associated with BPVL+ clones (26.4 years, 95% CI: 24.9-27.9) was significantly lower ($p<0.001$) than for BPVL- clones (36.0 years, 95% CI: 34.2-37.6). By risk factors of interest, of 1,284 total associated episodes for BPVL+ and BPVL- clones: 389 (30%) were coded for trauma, 302 (24%) for type II diabetes mellitus, 150 (12%) for mental or behavioural disorders, 120 (9%) for complications of surgical and medical care, 109 (8%) for renal failure, 67 (5%) for skin ulcers, 57 (4%) for conditions occurring in the obstetric or perinatal period, 53 (4%) for scabies, 39 (3%) for burns or corrosions, 21 (2%) for ischaemic heart disease and 18 (1%) for care involving use of rehabilitation procedures. There were a significantly higher number of associated episodes coded for type II diabetes mellitus, mental or behavioural disorders, renal failure, complications of surgical and medical care, skin ulcers, conditions occurring in the obstetric or perinatal period, care involving use of rehabilitation procedures, and ischaemic heart disease for BPVL- compared to BPVL+ clones ($p<0.05$ for all). There was no significant difference in the number of associated episodes coded for scabies and burns or corrosions between BPVL+ and BPVL- clones ($p=0.42$, $p=0.47$, respectively).
Where data were available for complete years, for BPVL+ clones, numbers of associated episodes increased from <5 in 2004 to 179 in 2014; an increase of a factor of over 30 (Table 4-1). For BPVL- clones, numbers of associated episodes increased from 41 in 2004 to 69 in 2014; an increase of a factor of 1.7 (Table 4-1). The overall mean length of stay for admitted episodes of care associated with BPVL+ clones was 4.8 days (95% CI: 4.2-5.4) and for BPVL- clones, 10.9 days (95% CI: 7.8-14.0) (Table 4-1). There was no significant trend in the mean length of stay over the study period for admitted episodes of care associated with notifications of BPVL+ clones ($p$=0.16). There was a decreasing trend in the mean length of stay over the study period for admitted episodes of care associated with notifications of BPVL- clones however the change did not reach significance at the 5% level ($p$=0.05). There was a significant decreasing trend over time in the proportion of persons notified with BPVL+ clones that were associated with at least one admitted episode of care ($p$$<$$0.001$ for both).

The overall mean length of stay for admitted episodes of care associated with BPVL+ clones was significantly lower ($p$$<$$0.001$) than the mean length of stay for admitted episodes of care associated with BPVL- clones. The total proportion of persons notified with BPVL+ clones with an associated episode (21%) was significantly lower ($p$$<$$0.001$) than the proportion for BPVL- clones (30%).

Only one admitted episode of care was associated with the 9 individuals notified with 10 Micro-Alert C clones. This single associated episode is not described in any more detail.
Table 4-1 Number of episodes, average length of stay and proportion of persons notified with CA-MRSA with an associated episode; by year of notification and Micro-Alert Category/PVL status analysed by year of admission

<table>
<thead>
<tr>
<th>Year</th>
<th>Micro-Alert B PVL +</th>
<th></th>
<th>Micro-Alert B PVL -</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Episodes (n)</td>
<td>Av. LOS (days) [95% CI]</td>
<td>n/n (%) persons CA-MRSA with associated episode</td>
<td>Episodes (n)</td>
</tr>
<tr>
<td>2003a</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td>2004</td>
<td>supp</td>
<td>2.7 [0.9-4.4]</td>
<td>supp (100)</td>
<td>41</td>
</tr>
<tr>
<td>2005</td>
<td>supp</td>
<td>1.7 [0.4-3.0]</td>
<td>supp (23)</td>
<td>38</td>
</tr>
<tr>
<td>2006</td>
<td>supp</td>
<td>27.0 [&lt;1-73.1]</td>
<td>supp (33)</td>
<td>34</td>
</tr>
<tr>
<td>2007</td>
<td>13</td>
<td>3.3 [1.8-4.8]</td>
<td>12/30 (40)</td>
<td>41</td>
</tr>
<tr>
<td>2008</td>
<td>supp</td>
<td>5.0 [&lt;1-10.2]</td>
<td>supp (15)</td>
<td>45</td>
</tr>
<tr>
<td>2009</td>
<td>16</td>
<td>5.4 [2.8-8.0]</td>
<td>15/72 (21)</td>
<td>39</td>
</tr>
<tr>
<td>2011</td>
<td>73</td>
<td>4.9 [3.4-6.4]</td>
<td>69/286 (24)</td>
<td>58</td>
</tr>
<tr>
<td>2012</td>
<td>105</td>
<td>4.8 [3.7-5.8]</td>
<td>102/503 (20)</td>
<td>60</td>
</tr>
<tr>
<td>2013</td>
<td>146</td>
<td>4.7 [3.1-6.3]</td>
<td>142/644 (22)</td>
<td>52</td>
</tr>
<tr>
<td>2014</td>
<td>179</td>
<td>4.7 [3.5-5.8]</td>
<td>175/979 (18)</td>
<td>69</td>
</tr>
<tr>
<td>TOTAL</td>
<td>699</td>
<td>4.8 [4.2-5.4]</td>
<td>653/3,159* (21)</td>
<td>585</td>
</tr>
</tbody>
</table>

*aData for half years

supp: Counts less than five are suppressed to maintain anonymity

Av. LOS= mean length of stay

95% CI = 95% confidence interval

**totals may not reflect row column total as an individual may have a notification in multiple years
4.7.2.2 Diagnoses of interest

Of the 699 associated episodes for BPVL+ clones, 520 (74%) contained at least one principal or additional code for any of the following diagnoses of interest, in descending order of frequency: abscess (359 episodes), cellulitis (176), osteomyelitis (21), impetigo (19), sepsis (17), pneumonia (13), urinary tract infection (uti) (11), arthritis (8) and endocarditis (<5). Note that one associated episode may contain codes for multiple diagnoses of interest. Of the 585 associated episodes for BPVL- clones, 301 (51%) contained at least one code for any of the diagnoses of interest, in descending order of frequency: cellulitis (145 episodes), abscess (90), sepsis (34), pneumonia (26), urinary tract infection (uti) (23), osteomyelitis (19), impetigo (17), arthritis (8) and endocarditis (<5).

Figure 4-4 shows the number of associated episodes by diagnosis of interest, Micro-Alert Category/PVL status and year. There was no significant trend over time in the proportion of associated episodes by each diagnoses of interest for BPVL+ or BPVL- associated episodes (p>0.05 for all). There were a significantly higher number of associated episodes coded for abscess and a significantly lower number of associated episodes coded for sepsis, pneumonia and urinary tract infection for BPVL+ clones compared to BPVL- clones (p<0.001, p=0.002, p=0.007, p=0.009, respectively). There was no significant difference in the number of associated episodes coded for cellulitis, osteomyelitis, impetigo, arthritis and endocarditis between BPVL+ and BPVL- clones (p=0.87, p=0.80, p=0.84, p=0.72, p=0.67, respectively).

The invasive to non-invasive ratio was 1:12 (48:578) and 1:5 (62:301) for BPVL+ and BPVL- associated episodes, respectively. The invasive to non-invasive ratio was significantly higher for BPVL- compared to BPVL+ associated episodes (p<0.001).

Figure 4-4. Number of associated episodes by diagnosis of interest, Micro-Alert Category/PVL status and year of admission. Note the different scales on the x-axis.
4.7.2.3 Procedures of interest

For BPVL+ clones, for persons with a diagnosis of skin and soft tissue infection (SSTI) (abscess, cellulitis or impetigo), there were a total of 303 procedures of aspiration, incision, excision or drainage over the study period (range: 0-69 per year) (Table 4-2). For BPVL- clones, there were a total of 97 procedures of interest (range: <5-17 per year) (Table 4-2). For BPVL+ clones there was a significant decreasing trend over time in the proportion of persons requiring a procedure of interest ($p=0.003$). There was no significant trend over time in the proportion of persons requiring a procedure of interest for BPVL- clones ($p=0.18$). Of persons with a diagnosis of SSTI, there was a significantly higher proportion of persons that underwent a procedure of interest for BPVL+ compared to BPVL- clones ($p<0.001$).

There were no procedures of interest coded in the single associated episode care for Micro-Alert C clones.

Table 4-2. Number of related procedures and proportion of persons with skin-related diagnoses requiring a procedure of interest, by Micro-Alert Category/PVL status and year

<table>
<thead>
<tr>
<th>Year</th>
<th>B, PVL+</th>
<th>B, PVL-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aspiration, Incision, Excision or Drainage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedures (n)</td>
<td>n/n (%) persons with related procedure</td>
</tr>
<tr>
<td>2003*</td>
<td>0</td>
<td>0/0 (0)</td>
</tr>
<tr>
<td>2004</td>
<td>supp</td>
<td>supp (100)</td>
</tr>
<tr>
<td>2005</td>
<td>supp</td>
<td>supp (100)</td>
</tr>
<tr>
<td>2006</td>
<td>supp</td>
<td>supp (100)</td>
</tr>
<tr>
<td>2007</td>
<td>8</td>
<td>7/10 (70)</td>
</tr>
<tr>
<td>2008</td>
<td>supp</td>
<td>supp (50)</td>
</tr>
<tr>
<td>2009</td>
<td>10</td>
<td>6/10 (60)</td>
</tr>
<tr>
<td>2010</td>
<td>19</td>
<td>17/26 (65)</td>
</tr>
<tr>
<td>2011</td>
<td>39</td>
<td>34/55 (62)</td>
</tr>
<tr>
<td>2012</td>
<td>41</td>
<td>35/68 (51)</td>
</tr>
<tr>
<td>2013</td>
<td>69</td>
<td>61/102 (60)</td>
</tr>
<tr>
<td>2014</td>
<td>69</td>
<td>58/123 (47)</td>
</tr>
<tr>
<td>2015*</td>
<td>38</td>
<td>35/74 (47)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>303</td>
<td>254/453 (56)</td>
</tr>
</tbody>
</table>

*Data for half years

supp: Counts less than five are suppressed to maintain anonymity
4.7.3 Emergency presentations

In total there were 2,045 emergency presentations during which at least one notification of CA-MRSA was made. For BPVL+ clones, there were a total of 1,361 emergency presentations associated with a notification. For complete years, the number of emergency presentations associated with BPVL+ clones increased over time; from <5 in 2004 to 384 in 2014. For BPVL- clones, there were a total of 680 emergency presentations associated with a notification and the number also increased over time; from 27 in 2004 to 118 in 2014. The average age of persons presenting to emergency associated with BPVL+ clones was significantly lower (25.6 years, 95% CI: 24.6-26.6) compared to BPVL- clones (31.4 years, 95% CI: 29.9-32.9) (p<0.001).

There was no significant trend over time in the proportion of persons presenting to the emergency department (ED) (p=0.96) for BPVL+ clones, but for BPVL- clones, there was a significant increasing trend over time in the proportion of persons presenting to ED (p<0.001). For BPVL+ clones, there was a significant decreasing trend over time in the proportion of persons presenting to ED that were subsequently admitted to hospital (p=0.007) and for BPVL- clones, there was no significant trend over time in the proportion of persons admitted (p=0.08). There was no significant trend over time in the proportion of presentations due to skin-related disease for BPVL+ clones (p=0.08) and a significant increasing trend for BPVL- clones (p<0.001).

For BPVL+ clones, of the 3,159 persons notified with a clone, 1,282 (41%) presented to the ED and for BPVL- clones, of the 1,754 persons notified with a clone, 610 (35%) presented to the ED. A significantly higher proportion of persons notified with a BPVL+ clone presented to the ED compared to BPVL- clones (p<0.001). The total proportion of presentations resulting in admission to hospital was significantly lower for BPVL+ clones than for BPVL- clones (p<0.001). For BPVL+ clones, in total, 74% of presentations were due to a skin-related disease which was significantly higher than the proportion for BPVL- clones (55%) (p<0.001).

For Micro-Alert C clones, there were less than five associated emergency presentations and none resulted in an admission to hospital.
Table 4-3. Number of associated emergency presentations, proportion of persons presenting, proportion admitted to hospital and proportion with a skin-related diagnosis, by Micro-Alert Category/PVL status and year of presentation

<table>
<thead>
<tr>
<th></th>
<th>Micro-Alert B PVL +</th>
<th></th>
<th>Micro-Alert B PVL -</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presentations (n)</td>
<td>n/n (%) persons CA-MRSA with presentation</td>
<td>% admitted</td>
<td>% skin related</td>
</tr>
<tr>
<td>2003&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0</td>
<td>0/0 (0)</td>
<td>0/0 (0)</td>
<td>0/0 (0)</td>
</tr>
<tr>
<td>2004</td>
<td>supp</td>
<td>supp (100)</td>
<td>supp (100)</td>
<td>supp (0)</td>
</tr>
<tr>
<td>2005</td>
<td>supp</td>
<td>supp (50)</td>
<td>supp (43)</td>
<td>supp (100)</td>
</tr>
<tr>
<td>2006</td>
<td>supp</td>
<td>supp (56)</td>
<td>supp (40)</td>
<td>supp (80)</td>
</tr>
<tr>
<td>2007</td>
<td>12</td>
<td>12/30 (40)</td>
<td>supp (50)</td>
<td>supp (50)</td>
</tr>
<tr>
<td>2008</td>
<td>supp</td>
<td>supp (35)</td>
<td>supp (25)</td>
<td>supp (50)</td>
</tr>
<tr>
<td>2009</td>
<td>27</td>
<td>25/72 (35)</td>
<td>supp (26)</td>
<td>17/27 (63)</td>
</tr>
<tr>
<td>2010</td>
<td>43</td>
<td>42/129 (33)</td>
<td>17/43 (40)</td>
<td>33/43 (77)</td>
</tr>
<tr>
<td>2011</td>
<td>116</td>
<td>116/285 (41)</td>
<td>39/116 (34)</td>
<td>90/116 (78)</td>
</tr>
<tr>
<td>2012</td>
<td>202</td>
<td>197/500 (39)</td>
<td>66/202 (33)</td>
<td>143/202 (71)</td>
</tr>
<tr>
<td>2013</td>
<td>262</td>
<td>256/646 (40)</td>
<td>101/262 (39)</td>
<td>201/262 (77)</td>
</tr>
<tr>
<td>2014</td>
<td>384</td>
<td>372/979 (38)</td>
<td>126/384 (33)</td>
<td>287/384 (75)</td>
</tr>
<tr>
<td>2015&lt;sup&gt;a&lt;/sup&gt;</td>
<td>293</td>
<td>289/731 (40)</td>
<td>70/293 (24)</td>
<td>226/293 (77)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,361</td>
<td>1,282/3,159 (41)</td>
<td>441/1,361 (32)</td>
<td>1,018/1,361 (75)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Data for half years

 supp: counts of 10 or less are suppressed to maintain anonymity
4.7.4 Severity indicators

For Micro-Alert B clones, Table 4-4 summarizes trends in the key indicators of clinical severity used throughout this report; from 2003 to 2015 and by PVL status. The majority of indicators suggest that clinical severity did not increase with time and in fact may have decreased. For both BPVL+ and BPVL- clones, the proportion of persons notified with CA-MRSA where the positive sample was collected during an admitted episode of care decreased with time. For BPVL+ clones, the proportion of persons with SSTI undergoing aspiration, incision, excision or drainage decreased with time and the proportion of emergency presentations resulting in admission to hospital decreased with time. For BPVL- clones, the mean length of stay appeared to decrease over time, however this trend was not statistically significant. However, for BPVL- clones, the proportion of persons notified with CA-MRSA where the positive sample was collected at presentation to emergency increased with time.

The majority of indicators suggest that the clinical severity associated with BPVL+ clones is lower than for BPVL- clones. Compared to BPVL+ clones, notifications of BPVL- clones were associated with a greater proportion of detections being made during an admitted episode of care, a greater proportion of emergency presentations resulting in admission to hospital, a longer average length of stay in hospital care and a higher proportion of invasive vs. non-invasive infections. However, notifications with BPVL+ clones were associated with a greater proportion of CA-MRSA detections being made at emergency presentation and a greater proportion of persons with SSTI undergoing a related procedure (aspiration, incision, excision or drainage) compared to BPVL- negative clones.

Table 4-4. Summary of indicators of severity over time and across PVL status for Micro-Alert B clones

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>% persons with associated episode</td>
<td>DECREASING</td>
<td>LOWER</td>
</tr>
<tr>
<td>Av. LOS</td>
<td>No trend</td>
<td>LOWER</td>
</tr>
<tr>
<td>I:NI</td>
<td>-</td>
<td>LOWER</td>
</tr>
<tr>
<td>% persons with related procedure</td>
<td>DECREASING</td>
<td>HIGHER</td>
</tr>
<tr>
<td>% persons with ED presentation</td>
<td>No trend</td>
<td>HIGHER</td>
</tr>
<tr>
<td>% ED presentations admitted to hospital</td>
<td>DECREASING</td>
<td>LOWER</td>
</tr>
</tbody>
</table>

Av. LOS= Average length of stay

I:NI: Invasive to non-invasive ratio
4.8 DISCUSSION

4.8.1 Main findings

From 2005/06 to 2014/15, the number of notifications of CA-MRSA for persons residing in the Kimberley region increased each year. Aboriginal and Torres Strait Islander people comprise approximately 40% of the region’s population but 87% of all notifications. This disproportionate burden is reflected in the high CA-MRSA notification rates for Aboriginal and Torres Strait Islander persons compared to non-Indigenous persons. The proportion of total notifications and notification rates of CA-MRSA for Aboriginal and Torres Strait Islander persons are increasing with time, with a particularly rapid rate increase from 2013 to 2015. In 2015, 1 in 10 of the Aboriginal and Torres Strait Islander population had a notification of CA-MRSA.

Previous studies conducted in northern areas of Australia found an increasing incidence of MRSA isolation from 2001 to 2011 in Aboriginal and Torres Strait Islander persons and a higher incidence of CA-MRSA infections compared to non-Indigenous persons. A study conducted in the Northern Territory found that high incidence rates of CA-MRSA infection in Aboriginal and Torres Strait Islander persons were associated with measures of remoteness and socio-economic disadvantage. Overcrowding, poor housing conditions and relative inaccessibility of healthcare are likely to be more common in remote locations and may perpetuate the ongoing transmission of circulating CA-MRSA clones and the prevalence of risk factors for CA-MRSA infection (e.g. scabies, streptococcal skin infection, ear infections). The frequent use of antimicrobial drugs to treat conditions such as scabies and other skin, respiratory and ear infections may contribute to the emergence of new CA-MRSA clones through de novo resistance acquisition. The very rapid CA-MRSA notification rate increase over the last two years may indicate an ongoing outbreak and may require molecular epidemiological surveillance to understand the dynamics of infection in this population.

One of the main aims of this study was to assess whether the number and proportion of notifications of CA-MRSA in the Kimberley that are detected during hospital admission or at presentation to the emergency department are changing with time. This gives an indication of the burden of this infection on state health-care services as well as a measure of clinical severity. An increasing proportion of persons detected with CA-MRSA during an admitted episode of care or at emergency presentation is considered to indicate increasing clinical severity of infection. As only small numbers of Micro-Alert C clones were notified over the study period, the discussion will concentrate mainly on trends for Micro-Alert B clones. However, it is acknowledged that Micro-Alert C clones have the ability to influence clinical severity if notifications do increase with time. The number of admitted episodes of care and emergency presentations associated with a positive detection of CA-MRSA increased from
the start to the end of the study period. This is expected simply due to the increase in the number of notifications of CA-MRSA with time. In total, 21% of CA-MRSA notifications were diagnosed during an admitted episode of care for BPVL+ clones and 30% for BPVL- clones. The proportion of notifications detected during an admitted episode of care decreased over the study period for both BPVL- and BPVL- clones. In total, 41% of CA-MRSA notifications were diagnosed at emergency presentation for BPVL+ clones and 35% for BPVL- clones. There was no time trend in the proportion of notifications diagnosed at emergency presentation for BPVL+ clones and an increasing proportion over time for BPVL- clones.

As the number of CA-MRSA infections are increasing with time, the number of associated admissions and emergency presentations are expected to also increase, adding additional burden to health services. A large proportion of this burden is experienced by emergency departments. The majority of indicators here suggest that clinical severity is not increasing with time and may in fact be decreasing. This may be due to increased testing and better clinical management by general practitioners. An exception is the proportion of CA-MRSA detections made at emergency presentation which is increasing for BPVL- clones; further adding to the expected burden on emergency departments in the future.

A second objective of this study was to characterise admitted episodes of care and emergency presentations associated with positive detections of CA-MRSA by admission length, reasons for admission or presentation, and procedures of interest. The mean length of stay for BPVL+ clones was 4.8 days [95% CI: 4.2-5.4] and for BPVL- clones, 10.9 days [95% CI: 7.8-14.0]. The majority of admitted episodes of care where CA-MRSA was detected were associated with abscesses and cellulitis in the patient. This result is expected given that the majority of CA-MRSA isolates from inpatients in a national survey were collected from skin and soft tissue infections.20 Associated episodes of care were also associated with sepsis, osteomyelitis, pneumonia, urinary tract infections, arthritis and endocarditis. The majority of associated diagnoses were classified as non-invasive rather than invasive; also in agreement with the national survey.20 For BPVL+ clones, one in every two persons with SSTI underwent surgical treatment for their infection (excision, incision, drainage or aspiration) and for BPVL- clones, approximately one in every three persons underwent surgical treatment. This finding agrees with a study that found approximately 50% of inpatients diagnosed with CA-MRSA in a Northern Territory hospital required surgical intervention.7 For BPVL+ clones, 75% of associated emergency presentations were due to skin-related disease and for BPVL- clones, 55%. These results highlight the common association of CA-MRSA with SSTIs and although less common, these pathogens do have the potential to cause more invasive infections. A substantial proportion of admitted episodes of care and ED presentations were not coded for any of the expected
clinical diagnoses related to CA-MRSA infections. ICD-10-AM diagnosis codes are assigned based on the rigid conventions of the ICD-10-AM/ACHI classifications; the Australian Coding Standards; and other mandatory national/state coding instructions. Not all current conditions in the patient, i.e. positive MRSA pathology result, will meet the rigid criteria for code assignment in an admitted episode of care. Also, there may be diseases that CA-MRSA infections are contributing to that are not traditionally analysed (e.g. infections during the perinatal period).

The third main objective of this study was to investigate whether the use of hospital services and the clinical severity of infections were greater for persons notified with BPVL+ compared to BPVL-clones. The overall number of associated episodes, procedures and associated presentations were greater for BPVL+ compared to BPVL- clones however this is expected due to the greater number of notifications for BPVL+ clones. The majority of indicators suggest that the clinical severity of disease associated with infections due to BPVL+ clones is less severe than for infection with BPVL- clones. There is ongoing debate regarding the predictive value of the presence of PVL genes for enhanced virulence. No consensus exists in the literature; some studies find positive associations between disease severity and the presence of PVL genes\(^7\) and some studies find a negative association.\(^{21}\)

Perhaps infections caused by BPVL+ clones are more likely to cause acute skin-related disease compared to BPVL- clones. This would explain the increased proportion of persons receiving emergency care, and skin-infection related surgical procedures for BPVL+ compared to BPVL-clones. In hospital screening programmes of patients and staff in Western Australia, approaches have traditionally targeted PVL+ clones.\(^{22}\) These results highlight the importance of not underestimating the ability of PVL- clones to cause severe infections and depending on the objectives of screening programmes, it may be more appropriate in the future to target all CA-MRSA strains.

This study supports the results of previous work that showed the mean age of persons with a PVL positive CA-MRSA infection was significantly lower than the mean age of persons with a PVL negative CA-MRSA infection.\(^{23}\) Compared to notifications of BPVL- clones, persons notified, admitted to hospital and presenting to the emergency department were younger for BPVL+ clones. With notifications of the BPVL+ Queensland ST93-IV [2B] clone rapidly increasing with time, a younger cohort are being diagnosed with CA-MRSA infections which may result in decreased quality-adjusted life years (QALYs) for persons infected with CA-MRSA in the Kimberley. From 2013 to 2015, notification rates of CA-MRSA for Aboriginal and Torres Strait Islander persons in the Kimberley increased more rapidly for females compared to males. Previous studies have shown that methicillin resistance in \textit{S. aureus} isolates was higher for samples collected from females compared to males.\(^{6,7}\) An explanation given in one of these studies for the association between females and methicillin resistance was the greater frequency and duration of women’s contact with children.\(^6\)
would be important to investigate the recent trend further to determine whether females are at a greater risk of CA-MRSA infection, and if so, what specific public health interventions may be implemented to reduce the problem.

Compared to persons diagnosed with BPVL+ clones, a significantly higher proportion of persons diagnosed with BPVL- clones had chronic co-morbid conditions such as renal failure, type II diabetes mellitus and ischaemic heart disease. It appears that, for unknown reasons, characteristics of persons notified with BPVL+ CA-MRSA clones differ to those notified with BPVL- CA-MRSA clones. Perhaps BVPL+ clones are able to infect younger healthier persons while BPVL- clones require reduced fitness in the host for infection and disease. This may explain the significantly higher average length of stay for admitted episodes of care associated with BPVL- clones compared to BPVL+ clones. This result may also explain the higher proportion of admitted episodes of care and emergency presentations that were not coded for a diagnosis of interest for CA-MRSA infections. Conversely, if a large proportion of BPVL- infections occur through nosocomial acquisition, then the persons at risk for infection may generally be older and have a higher prevalence of co-morbid conditions. A previous study found that nationally in 2011, BPVL- clones made up the largest proportion of isolates of CA-MRSA obtained from hospital-onset samples. A significantly higher number of admitted episodes of care were coded as complications of surgical or medical care for BPVL- compared to BPVL+ clones. Perhaps PVL- clones are more prevalent in hospital environments or in persons more likely to require hospitalisation, thus confounding the assessment of clinical severity by PVL status.

4.8.2 Study strengths
The study’s strengths lie in the use of a comprehensive dataset of CA-MRSA notifications with data linkage, the analysis of admitted episodes of care and emergency presentations during which positive specimens were collected and the sensitivity of the clinical codes used to detect and classify related diagnoses, procedures and risk factors.

This study is the first attempt to link CA-MRSA notification data to admitted episode of care and emergency records in order to assess the use of health-services due to or related to this organism over time. As detections of MRSA in the Kimberley are notifiable and because ACCESS apply consistent diagnostic and classification techniques to the isolates, a comprehensive dataset of CA-MRSA notifications allowed the analyses of trends in notifications over time. The completeness of the Indigenous status field was achieved through data linkage algorithms and allowed the analysis of notification rates over time by Indigenous status. Due to the increasing number of CA-MRSA notifications over the study period, it was expected that the number of associated admitted episodes of care and ED records would also increase over time. Grounding the number of admitted episodes
of care and emergency presentations with the number of total notifications of CA-MRSA in the region allowed the assessment of any changes to the use of health-care services and gave an estimate of the clinical severity of infections with time. In the absence of linking notification data to admitted episodes of care, admissions related to CA-MRSA infections are usually flagged using ICD-10-AM codes for *S. aureus* (B95.6) and a marker of antimicrobial resistance (Z06). Of the 699 admitted episodes of care where a positive BPVL+ specimen was collected, only 430 (62%) records contained these codes. Of the 585 admitted episodes of care where a positive BPVL- specimen was collected, only 218 (37%) records contained these codes. Linking notification data to hospital admission records was a sensitive method of detecting associated episodes of care where coding indicative for CA-MRSA infection may not be used.

Notification data could have been linked to admitted episodes of care and ED presentations that occurred any number of weeks/months before or after the date of collection. It was decided for this study to analyse the number of admitted episodes of care and ED presentations where a positive specimen was collected during the time of admitted care or at emergency presentation. This increased the confidence that the reason for admission and presentation was caused by or related to the patient’s CA-MRSA infection.

Care was taken to ensure that the assignment of ICD-10-AM codes to diagnoses of interest included any changes to coding practices over the time of the study period. Also, thorough searches of ICD-10-AM and ACHI codes were undertaken to increase the sensitivity of detection of any diagnosis or procedure of interest in the admitted episode of care dataset. As codes for skin-related conditions were more likely to be found in the additional rather than principal diagnosis fields, all diagnosis fields were queried for the relevant codes; again to increase sensitivity of detection.

### 4.8.3 Study limitations

The use of notification data precludes the assessment of the burden of CA-MRSA infections in individuals that do not present to health care or who are not swabbed and this study is unable to include residents of the Kimberley who attend hospital care outside of Western Australia. It is outside the scope of this study to examine the use of general practice services. In the Kimberley there are remote and town community clinics and a number of Royal Flying Doctor Service clinics that may treat patients for CA-MRSA but these presentations are not included in this analysis. Also, this study does not measure admitted episodes of care or ED presentations for persons that have a positive specimen collected prior to or after the admitted episode of care or emergency presentation. Duplicate isolates for an individual were excluded from analysis and therefore admitted episodes of care or emergency presentations associated with duplicate isolates were not counted. For these reasons, the
results presented in this study are likely to be an underestimate of the true burden of this infection in the community and to health-care providers.

The assessment of trends in CA-MRSA notifications over time assumes that testing practices for the diagnosis of CA-MRSA remain relatively stable over time. Testing denominator data were unable to be included in this study but would be important to include in any future study to determine the influence of increased testing practices on increasing trends in CA-MRSA notifications. From the available literature and anecdotal evidence, it is likely that increased notification rates are due to a combination of more samples being tested and an increased prevalence in the community.8,23,24

The assessment of clinical severity of CA-MRSA infections over time assumes a similar pattern of health-care seeking behaviour and health-care provision over time. If for some reason during the study period behaviours or clinical management practices changed, this would affect the interpretation of any trends. If for example, half way through the study period, if persons were more likely to attend GP clinics for diagnosis and treatment of CA-MRSA infection instead of going to the emergency department then clinical severity would appear to decrease with time, and vice versa. It would be important in future research to include GP consultations for CA-MRSA infections both to achieve a more complete picture of the burden of infection on the health-care system, to detect any changes in behaviour and clinical management practices and to determine where best to target public health messaging and resources.

In the assessment of the relative clinical severity associated with BPVL+ compared to BPVL- clones, this study did not include a description of changes in the antimicrobial resistance phenotype of isolates. Differential attainment of resistance to additional classes of antimicrobials for one PVL type compared to the other may influence clinical management and result in longer lengths of stay for example. A recent national study of CA-MRSA isolated from outpatients found an overall low rate of resistance to antimicrobials other than β-lactam antimicrobials.25 However this study did find that 20 (6%) isolates which included Micro-Alert C clones were multi-resistant.25 This emphasizes the importance of continued surveillance for CA-MRSA both in inpatients and outpatients to determine any change in the epidemiology of circulating clones and how the development of resistance influences clinical outcomes.

This study does not differentiate between CA-MRSA infections that were acquired in the community or in the hospital environment. This was outside the scope of this study but may have been achieved by identifying hospital-onset infections as positive specimens collected 48 hours after a formal admission to hospital.20 Nosocomial acquisition of CA-MRSA clones is increasing26 and a recent national survey found that 12% of all S. aureus isolates from inpatients were CA-MRSA clones.20
Hospital-acquired infections may be associated with more severe outcomes than community-acquired infections due to confounding factors such as age, co-morbidities and invasive procedures. There were a number of associated episodes that were coded as complications of surgical or medical care. In future studies that compare the severity of clinical outcomes between PVL- and PVL+ clones, it would be important to control for the confounder of place of acquisition of infection (community or hospital).

4.9 CONCLUSION
This study has shown increasing notifications of CA-MRSA in the Kimberley region of Western Australia with a particularly high burden for Aboriginal and Torres Strait Islander persons. A rapid increase in the number of notifications of BPVL+ clones occurred over the last 10 years and raised concerns that the perceived increased virulence of PVL+ organisms would influence trends in hospital admissions, emergency presentations and the severity of disease. This study found that increased notifications of CA-MRSA in the region are associated with an increased burden on the state hospital system, particularly emergency departments. Per person, of those notified with CA-MRSA, overall the use of hospital inpatient services does not appear to be significantly increasing with time however it will be important to continue to conduct clinical and molecular surveillance of clones circulating in the community and in the hospital environment to detect any changes in virulence and environmental niches.

4.10 REFERENCES


## 4.11 APPENDICES

**Appendix 4-1. Isolates categorised by clone name, Micro-Alert Category, PVL status and international nomenclature, 1 July 2003 to 30 June 2015**

<table>
<thead>
<tr>
<th>Clone</th>
<th>Micro-Alert</th>
<th>PVL status</th>
<th>ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bengal Bay</td>
<td>C</td>
<td>Positive</td>
<td>ST772-V [5C2]</td>
</tr>
<tr>
<td>USA 300</td>
<td>C</td>
<td>Positive</td>
<td>ST8-IV [2B]</td>
</tr>
<tr>
<td>Queensland</td>
<td>B</td>
<td>Positive</td>
<td>ST93-IV [2B]</td>
</tr>
<tr>
<td>WSPP</td>
<td>B</td>
<td>Positive</td>
<td>ST30-IV [2B]</td>
</tr>
<tr>
<td>WA 121</td>
<td>B</td>
<td>Positive</td>
<td>ST5-IV [2B]</td>
</tr>
<tr>
<td>Taiwan A</td>
<td>B</td>
<td>Positive</td>
<td>ST952-VT [5C2&amp;5]</td>
</tr>
<tr>
<td>WA 89</td>
<td>B</td>
<td>Positive</td>
<td>ST1633-V [5C2]</td>
</tr>
<tr>
<td>WA 109</td>
<td>B</td>
<td>Positive</td>
<td>ST5-V [5C2]</td>
</tr>
<tr>
<td>WA 1</td>
<td>B</td>
<td>Negative</td>
<td>ST1-IV [2B]</td>
</tr>
<tr>
<td>WA 2</td>
<td>B</td>
<td>Negative</td>
<td>ST78-IV [2B]</td>
</tr>
<tr>
<td>WA 3</td>
<td>B</td>
<td>Negative</td>
<td>ST5-IV [2B]</td>
</tr>
<tr>
<td>WA 4</td>
<td>B</td>
<td>Negative</td>
<td>ST45-V [5C2]</td>
</tr>
<tr>
<td>WA 5</td>
<td>B</td>
<td>Negative</td>
<td>ST8-IV [2B]</td>
</tr>
<tr>
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<td>B</td>
<td>Negative</td>
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</tr>
<tr>
<td>WA 23</td>
<td>B</td>
<td>Negative</td>
<td>ST45-IV [2B]</td>
</tr>
<tr>
<td>WA 25</td>
<td>B</td>
<td>Negative</td>
<td>ST75-IV [2B]</td>
</tr>
<tr>
<td>WA 34</td>
<td>B</td>
<td>Negative</td>
<td>ST5-V [5C2&amp;5]</td>
</tr>
<tr>
<td>WA 47</td>
<td>B</td>
<td>Negative</td>
<td>ST883-IV [2B]</td>
</tr>
<tr>
<td>WA 48</td>
<td>B</td>
<td>Negative</td>
<td>ST835-IV [2B]</td>
</tr>
<tr>
<td>WA 51</td>
<td>B</td>
<td>Negative</td>
<td>ST6-IV [2B]</td>
</tr>
<tr>
<td>WA 54</td>
<td>B</td>
<td>Negative</td>
<td>ST953-IV [2B]</td>
</tr>
<tr>
<td>WA 65</td>
<td>B</td>
<td>Negative</td>
<td>ST73-IV [2B]</td>
</tr>
<tr>
<td>WA 71</td>
<td>B</td>
<td>Negative</td>
<td>ST5-IV [2B]</td>
</tr>
<tr>
<td>WA 72</td>
<td>B</td>
<td>Negative</td>
<td>ST1304-IV [2B]</td>
</tr>
<tr>
<td>WA 75</td>
<td>B</td>
<td>Negative</td>
<td>ST45-IV [2B]</td>
</tr>
<tr>
<td>WA 76</td>
<td>B</td>
<td>Negative</td>
<td>ST1303-IV [2B]</td>
</tr>
<tr>
<td>WA 79</td>
<td>B</td>
<td>Negative</td>
<td>ST75-IV [2B]</td>
</tr>
<tr>
<td>WA 84</td>
<td>B</td>
<td>Negative</td>
<td>ST45-V [5C2&amp;5]</td>
</tr>
<tr>
<td>WA 97</td>
<td>B</td>
<td>Negative</td>
<td>STT2-novel (novel SCCmec)</td>
</tr>
<tr>
<td>WA 114</td>
<td>B</td>
<td>Negative</td>
<td>STNovel-IV [2B]  – the ST has not been determined</td>
</tr>
<tr>
<td>WA 121</td>
<td>B</td>
<td>Negative</td>
<td>ST5-IV [2B]</td>
</tr>
<tr>
<td>WA 133</td>
<td>B</td>
<td>Negative</td>
<td>STNovel-V [5C2]  – the ST has not been determined</td>
</tr>
</tbody>
</table>
### Appendix 4-2. Diagnoses and risk factors of interest to CA-MRSA infections and classifying ICD-10-AM code(s)

<table>
<thead>
<tr>
<th>Diagnosis of interest</th>
<th>ICD-10-AM code(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impetigo</td>
<td>L01</td>
</tr>
<tr>
<td>Abscess, furuncle and carbuncle (“abscess”)</td>
<td>L02, J34.0, K61, K04.7, L05.0, N76.4, O91.1</td>
</tr>
<tr>
<td>Cellulitis</td>
<td>L03, K12.2</td>
</tr>
<tr>
<td>Arthritis, bursitis (“arthritis”)</td>
<td>M00.0, M00.9, M71.1</td>
</tr>
<tr>
<td>Osteomyelitis</td>
<td>M86</td>
</tr>
<tr>
<td>Sepsis</td>
<td>A41.0, A41.1, A41.2, A41.5, A41.9, O85</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>I33.0, I01.1</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>J15.2, J18.9</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>N39.0, O23.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk factors of interest</th>
<th>ICD-10-AM code(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scabies</td>
<td>B86</td>
</tr>
<tr>
<td>Skin ulcer</td>
<td>L89, L97, L98.4</td>
</tr>
<tr>
<td>Burns and corrosions</td>
<td>T20-T31</td>
</tr>
<tr>
<td>Injuries, trauma, wounds “Trauma”</td>
<td>S00-T19, T79</td>
</tr>
<tr>
<td>Complications of surgical and medical care</td>
<td>T80-T88, O86.0</td>
</tr>
<tr>
<td>Care involving use of rehabilitation procedures</td>
<td>Z50</td>
</tr>
<tr>
<td>Pregnancy, childbirth and the puerperium, and conditions occurring in perinatal period</td>
<td>O00-P96</td>
</tr>
<tr>
<td>Type II diabetes mellitus</td>
<td>E11</td>
</tr>
<tr>
<td>Mental and behavioural disorders</td>
<td>F00-F99</td>
</tr>
<tr>
<td>Ischaemic heart disease</td>
<td>I20-I25</td>
</tr>
<tr>
<td>Renal failure</td>
<td>N17-N19</td>
</tr>
</tbody>
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### Appendix 4-3. Procedures of interest to CA-MRSA infections and classifying ACHI code

<table>
<thead>
<tr>
<th>ACHI code</th>
<th>Procedure description</th>
<th>Assigned category</th>
</tr>
</thead>
<tbody>
<tr>
<td>30216-01</td>
<td>Aspiration of abscess of skin and subcutaneous tissue</td>
<td>Aspiration</td>
</tr>
<tr>
<td>30216-02</td>
<td>Other aspiration of skin and subcutaneous tissue</td>
<td>Aspiration</td>
</tr>
<tr>
<td>50124-00</td>
<td>Aspiration of joint or other synovial cavity, not elsewhere classified</td>
<td>Aspiration</td>
</tr>
<tr>
<td>90725-00</td>
<td>Aspiration of breast</td>
<td>Aspiration</td>
</tr>
<tr>
<td>30023-00</td>
<td>Excisional debridement of soft tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>30023-01</td>
<td>Excisional debridement of soft tissue involving bone or cartilage</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>30099-00</td>
<td>Excision of sinus of skin and subcutaneous tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>30103-00</td>
<td>Excision of sinus involving soft tissue, not elsewhere classified</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>30223-01</td>
<td>Incision and drainage of abscess of skin and subcutaneous tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>30223-02</td>
<td>Other incision and drainage of skin and subcutaneous tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>30223-03</td>
<td>Incision and drainage of abscess of soft tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>30224-00</td>
<td>Percutaneous drainage of abscess of soft tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31205-00</td>
<td>Excision of lesion of skin and subcutaneous tissue of other site</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31205-01</td>
<td>Excision of ulcer of skin and subcutaneous tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31230-00</td>
<td>Excision of lesion of skin and subcutaneous tissue of eyelid</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31230-01</td>
<td>Excision of lesion of skin and subcutaneous tissue of nose</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31230-02</td>
<td>Excision of lesion of skin and subcutaneous tissue of ear</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31230-04</td>
<td>Excision of lesion of skin and subcutaneous tissue of finger</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31230-05</td>
<td>Excision of lesion of skin and subcutaneous tissue of genitals</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31235-00</td>
<td>Excision of lesion of skin and subcutaneous tissue of other site of head</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31235-01</td>
<td>Excision of lesion of skin and subcutaneous tissue of neck</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31235-02</td>
<td>Excision of lesion of skin and subcutaneous tissue of hand</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31235-03</td>
<td>Excision of lesion of skin and subcutaneous tissue of leg</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31235-04</td>
<td>Excision of lesion of skin and subcutaneous tissue of foot</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31350-00</td>
<td>Excision of lesion of soft tissue, not elsewhere classified</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>31551-00</td>
<td>Incision and drainage of breast</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>32174-01</td>
<td>Drainage of perianal abscess</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>46519-00</td>
<td>Incision and drainage of middle palmar, thenar or hypothenar spaces of hand</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>46525-00</td>
<td>Incision and drainage of paronychia of hand</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>47918-00</td>
<td>Radical excision of ingrown toenail bed</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>90545-00</td>
<td>Incision of soft tissue of hand</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>90568-02</td>
<td>Incision of soft tissue, not elsewhere classified</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>90575-00</td>
<td>Excision of soft tissue, not elsewhere classified</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>90661-00</td>
<td>Other incision of skin and subcutaneous tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>90665-00</td>
<td>Excisional debridement of skin and subcutaneous tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>90686-01</td>
<td>Nonexcisional debridement of skin and subcutaneous tissue</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>96215-00</td>
<td>Incision and drainage of lesion in oral cavity</td>
<td>Incision/Excision/Drainage</td>
</tr>
<tr>
<td>97392-00</td>
<td>Incision and drainage of abscess or cyst in oral cavity</td>
<td>Incision/Excision/Drainage</td>
</tr>
</tbody>
</table>
CHAPTER 5  OUTBREAK CHAPTER PART ONE: COHORT STUDY OF ACUTE GASTROENTERITIS AT A CATERED EVENT

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5.1 ROLE

Please note that due to privacy reasons, the affected workplace will be referred to as Workplace X and the implicated catering company will be referred to as Caterer X.

I was given the opportunity to assist ACT Health with this outbreak investigation. Laura Ford (OzFoodNet) supervised me throughout the investigation. The work that had already taken place before my involvement included interviews with nine cases, history collection from the meeting organiser, and the environmental and laboratory investigation and testing. I conducted nine interviews, crafted the case definition, performed the data analysis and wrote the epidemiological report for ACT Health.

5.2 LESSONS LEARNT

The main lesson I learnt from this outbreak investigation is not to jump to a conclusion too soon. Due to the high attack rate in the meeting attendees, the available evidence was pointing to the catered lunch as the source of exposure. For this reason, at the time of interview, ill interviewees were not asked in detail about potential prior exposures, including whether the same meeting attendees had convened at a date prior to the catered lunch. Using the catered lunch as the exposure, the incubation period did not fit with norovirus infection and thus available information on prior exposures would have been useful to better interpret the epidemiological and laboratory results.

5.3 PUBLIC HEALTH IMPORTANCE

Acute gastroenteritis is commonly caused by infection with norovirus. Norovirus is highly infectious and is transmitted primarily from person to person in confined settings such as cruise ships, schools, and nursing homes. In healthy individuals, norovirus infection is usually self-limiting, however severe and prolonged symptoms may occur in immunocompromised persons, the elderly and the young. Norovirus is the only human enteric virus known to cause pandemics of acute gastroenteritis. The Norovirus genus comprises seven genogroups (G), which can be further divided into more than 40 genotypes. Viruses of the GI, GII and GIV genogroups infect humans and since the mid-1990s, GII.4 viruses have caused the majority of outbreaks worldwide. Variants within genotypes arise due to genetic drift; antigenically novel variants emerge every two to three years and are able to cause widespread illness due to a lack of population immunity. Recently, in July 2016, a new variant of norovirus was implicated as the cause of increased cases of gastroenteritis in New South Wales. In the absence of a vaccine, surveillance of circulating norovirus genotypes is essential to detect a shift in the dominant variant and thus employ preventative measures such as improved hygiene in order to prevent illness in at-risk persons.
5.4 INITIAL NOTIFICATION
On 7 December 2015, the Health Protection Service (HPS) was notified of an outbreak of gastroenteritis following a meeting held at Workplace X and catered by Caterer X on 3 December 2015. It was reported that at least 7 of 20 meeting attendees were affected. An investigation was initiated with the aim of confirming the existence of the outbreak, characterising cases, and identifying the etiological agent and source of infection in order to inform control interventions and prevent future occurrences.

5.5 EPIDEMIOLOGICAL INVESTIGATION

5.5.1 Methods
A cohort study was performed to investigate the source of infection. The cohort included in this study was any person who attended the meeting held at Workplace X on Thursday 3 December 2015 and who consumed food from the catered lunch provided by Caterer X. The case definition for this outbreak was any person who experienced at least one of the following symptoms with onset from 3 December to 4 December 2015: diarrhoea, vomiting, or nausea. Diarrhoea was considered one or more loose stools from 3 to 4 December.

A list of all meeting attendees was obtained from the meeting organiser (the list indicated who was reportedly ill and who was not). A menu of food items served at the lunch was provided by Caterer X. All people who reported that they were unwell were contacted by phone on 4 December and interviewed using a standardised gastroenteritis questionnaire that was modified to include food items served on 3 December. All healthy persons were contacted by phone on 10 December and interviewed using an abridged version of the case questionnaire.

Data were captured and analysed using MS Excel and analysed using Stata version 13.

5.5.2 Results
All 18 persons who attended the meeting and consumed the catered food were interviewed. Eleven (11) persons met the case definition. The overall attack rate for the cohort was 61%.

Lunch was served at 13:00 on 3 December. Illness onset ranged from 15:30 on 3 December to 07:00 on 4 December with a median incubation period of 7 hours (range: 2.5-18 hours). The epidemic curve showing the date and time of illness onset is shown in Figure 5-1. The shape of the curve indicates a point-source outbreak.
Of the 11 cases, 8 (73%) were female and 3 (27%) were male. The mean age of cases was 45 years (range: 26-59 years). Cases did not differ significantly from controls by age or sex. Illness was characterised by diarrhoea (73%), nausea (73%), headache (73%), stomach cramps (70%), fatigue (64%), vomiting (55%), chills (18%), fever (9%), and muscle aches (9%). No cases reported bloody diarrhoea. Seven of the 11 cases reported that their symptoms had ceased at the time of interview, with a median duration of 8 hours (range: 1-24 hours). Two cases visited the GP, one had a faecal sample submitted for pathology, none were admitted to hospital, and no deaths were identified at the time of interview.

A univariate analysis was performed to measure the association between each food item served at the lunch and illness. Table 5-1 presents for each food item the results of the univariate analysis: attack rates, risk ratios with 95% confidence intervals, and associated p-values. Attack rates were 100% for the tandoori chicken and lettuce sandwich, and the salami, cheese and tomato sandwich. The risk ratios for these sandwiches were 2.17 (95% CI 1.20-3.90) and 1.78 (95% CI 1.15-2.74) respectively. However, these associations were not statistically significant (p>0.05). A multivariate analysis was not performed due to a lack of any significant association between any one food item and illness in the univariate analysis.
Table 5.1. Univariate analysis of the association between foods served and illness

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Total</th>
<th>Exposed</th>
<th>Unexposed</th>
<th>Risk Ratio [95% CI]</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>AR%</td>
<td>Cases</td>
<td>AR%</td>
<td></td>
</tr>
<tr>
<td>Ham, cheese and tomato sandwich</td>
<td>7</td>
<td>5</td>
<td>11</td>
<td>6</td>
<td>1.31 [0.64-2.68]</td>
</tr>
<tr>
<td>Tandoori chicken and lettuce sandwich</td>
<td>5</td>
<td>5</td>
<td>100</td>
<td>6</td>
<td>2.17 [1.20-3.90]</td>
</tr>
<tr>
<td>Egg and lettuce sandwich</td>
<td>5</td>
<td>3</td>
<td>60</td>
<td>8</td>
<td>0.98 [0.42-2.25]</td>
</tr>
<tr>
<td>Curried egg and lettuce sandwich</td>
<td>3</td>
<td>2</td>
<td>67</td>
<td>9</td>
<td>1.11 [0.45-2.73]</td>
</tr>
<tr>
<td>Turkey, avocado and lettuce sandwich</td>
<td>2</td>
<td>1</td>
<td>50</td>
<td>9</td>
<td>0.83 [0.20-3.54]</td>
</tr>
<tr>
<td>Plain salad sandwich</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Salami, cheese and tomato sandwich</td>
<td>2</td>
<td>2</td>
<td>100</td>
<td>9</td>
<td>1.78 [1.15-2.74]</td>
</tr>
<tr>
<td>Chicken sandwich</td>
<td>11</td>
<td>8</td>
<td>73</td>
<td>3</td>
<td>1.70 [0.67-4.30]</td>
</tr>
<tr>
<td>Scone</td>
<td>9</td>
<td>6</td>
<td>67</td>
<td>5</td>
<td>1.20 [0.57-2.53]</td>
</tr>
<tr>
<td>Mini spring rolls</td>
<td>16</td>
<td>11</td>
<td>69</td>
<td>2</td>
<td>0.80 [0.19-3.37]</td>
</tr>
<tr>
<td>Mini pies</td>
<td>11</td>
<td>7</td>
<td>64</td>
<td>4</td>
<td>1.11 [0.51-2.43]</td>
</tr>
<tr>
<td>Curry puffs</td>
<td>11</td>
<td>7</td>
<td>64</td>
<td>4</td>
<td>1.11 [0.51-2.43]</td>
</tr>
<tr>
<td>Fruit platter</td>
<td>8</td>
<td>6</td>
<td>75</td>
<td>5</td>
<td>1.50 [0.72-3.14]</td>
</tr>
<tr>
<td>Tea</td>
<td>2</td>
<td>1</td>
<td>50</td>
<td>10</td>
<td>0.80 [0.19-3.37]</td>
</tr>
<tr>
<td>Coffee</td>
<td>2</td>
<td>1</td>
<td>50</td>
<td>10</td>
<td>0.80 [0.19-3.37]</td>
</tr>
<tr>
<td>Sweet chilli sauce</td>
<td>8</td>
<td>3</td>
<td>38</td>
<td>1</td>
<td>1.13 [0.18-7.04]</td>
</tr>
<tr>
<td>Tomato sauce</td>
<td>6</td>
<td>3</td>
<td>50</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Milk</td>
<td>3</td>
<td>2</td>
<td>67</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

AR: attack rate, CI: confidence interval, P: p-value

5.6 FOOD INVESTIGATION

There were anecdotal reports that the cooked foods at the lunch were served warm, rather than hot, and that food preparation may have been done in a hurry (i.e. it was a late catering request). An inspection of the caterer’s premises was completed by a Public Health Officer from the HPS on 4 December 2015. An improvement notice was issued to address issues including sauce bottle practices, providing lids or covers for processed vegetables, repairing or replacing the liquid soap dispenser in the server, and inverting cutlery in the customer self-serve area to prevent handling of the eating ends. None of the food handlers were reportedly unwell. No leftover food from the catered lunch was available for testing however other foods prepared by the caterers were collected for testing.

5.7 LABORATORY INVESTIGATION

5.7.1 Human samples and results

Parasitic identification, bacterial culture, and virological testing were undertaken by ACT Pathology on a faecal specimen collected from one case. The specimen was negative for protozoan parasites, *Campylobacter*, *Salmonella*, *Shigella*, rotavirus, and adenovirus. The sample was positive for norovirus. Laura Ford and I attempted to arrange for Professor Peter White at UNSW to perform norovirus genotyping on the positive specimen however after re-testing of the specimen by the South Eastern Area Laboratory Services (SEALS) found the sample to be negative, the sample was discarded and not available for further testing.
5.7.2 Food samples and results

Five food samples were collected from Caterer X, namely: sliced salami, unsliced salami, sweet chilli sauce, cooked and shredded chicken, and sliced cucumbers. The samples were tested for *Salmonella*, *Clostridium perfringens*, *Escherichia coli*, *Staphylococcus aureus*, *Bacillus cereus*, and standard plate count. No pathogens were detected in any of the samples.

5.8 CONCLUSION

This outbreak was characterised by acute onset of gastroenteritis in a large proportion (61%) of individuals who attended and ate a catered lunch at a work meeting. Given available evidence, the food served at the lunch was the likely source of infection. The short calculated median incubation time of 7 hours and clinical syndrome dominated by diarrhoea, nausea, headache, and stomach cramps raised suspicion of a bacterial infection or toxin (*Bacillus*, *Clostridium perfringens*, nontyphoidal *Salmonella* or ETEC) as the causative agent.\(^\text{11}\) Confirmation of an outbreak due to these agents usually requires the isolation of the organism from two or more ill persons or the isolation of the organism from epidemiologically implicated food.\(^\text{11}\) Initial laboratory results did not detect any organism in either the food samples or the faecal specimen from one case. False negative laboratory results are not unusual for bacterial toxins, particularly for food samples.

Subsequent laboratory testing of the faecal sample detected norovirus. As only one specimen was tested, norovirus as the cause of the outbreak could not be confirmed and remains only suspected. Although the attack rate of this outbreak and the clinical syndrome corresponded to that expected for norovirus\(^\text{12-14}\), the median duration of illness (8 hours) was lower than the range expected for a norovirus outbreak according to Kaplan’s criteria (12 to 60 hours).\(^\text{14}\) Furthermore, with lunch as the time of exposure, the calculated median incubation time for this outbreak (7 hours) was much shorter than expected for norovirus infections (median=1.2 days).\(^\text{15}\) Thus using the catered lunch as the exposure, this outbreak did not meet the criteria of a norovirus outbreak according to Kaplan’s criteria.\(^\text{14}\)

Two hypotheses as to the causative agent exist:

1. Norovirus is the cause of the outbreak and exposure occurred prior to the work meeting (e.g. the meeting attendees convened before the Thursday)

2. Norovirus was a coincidental finding (shedding post-infection and recovery) and the cause of the illness in this outbreak was infection with bacteria or a bacterial toxin, possibly from one (or both) of the sandwiches with high risk ratios.
Information from the meeting organiser confirmed that the group had not met before the catered lunch. Information from the case positive for norovirus confirmed that they had not experienced any illness prior to the lunch. Thus, the available evidence suggests that exposure to the disease causing agent most likely occurred during the catered lunch event. Given the median incubation time and clinical syndrome, the causative agent of this outbreak was most likely bacterial or a bacterial toxin.

5.9 INVESTIGATION SUMMARY

- There were 11 cases of gastroenteritis identified among attendees of a catered meeting on 3 December.
- Given the high attack rate for attendees of the catered lunch and considering these people did not meet prior to the lunch, exposure to the disease causing agent most likely occurred at the lunch.
- Norovirus was detected in one stool specimen collected from one case. Using lunch as the time of exposure, the median incubation time and median duration of illness were lower than expected for a typical outbreak of norovirus.
- The relatively short median incubation time and the clinical syndrome suggests that the most likely cause of this outbreak was infection with a bacteria or bacterial toxin. Norovirus was likely a coincidental finding.
- The cause of this outbreak was not confirmed.
- The analytical study suggested that no one particular food item was responsible for the illness.

5.10 REFERENCES


CHAPTER 6 OUTBREAK CHAPTER PART TWO: EVENT-BASED SURVEILLANCE AT THE WORLD HEALTH ORGANIZATION’S WESTERN PACIFIC REGIONAL OFFICE

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6.1 INTRODUCTION TO THE PLACEMENT
At the end of my first year of the MAE I was given the opportunity to work as a Rumour Surveillance Officer at the World Health Organization (WHO)’s Western Pacific Regional Office (WPRO) in Manila, the Philippines. From 16 December 2015 to 12 February 2016, I was employed as a short-term consultant to conduct event-based surveillance (EBS) for the Region on a daily basis. The Rumour Surveillance Officer role was part of the Emerging Disease Surveillance and Response Unit (ESR) within the Division of Health Security and Emergencies (DSE). The two other Units that compose DSE are the Disaster Risk Management Unit (DRM) and the Food Safety Unit. The Division of Health Security and Emergencies works with Member States and Partners to develop and advance national and regional capacities to deal with health security threats. During this period, Dr Takuya Yamagishi was the Surveillance Team Leader, Dr Babatunde Olowokure was the Coordinator of ESR, Dr Li Ailan was the Director of DSE and Dr Shin Young-soo was the Regional Director.

6.2 THE WORLD HEALTH ORGANIZATION
The World Health Organization is the United Nations specialised agency for health.\(^1\) It is made up of 194 Member States, six regional offices and a headquarters in Geneva.\(^1\) The World Health Organization has six leadership priorities that give focus and direction to its work:\(^1\)

1. Advancing universal health coverage
2. Implementing the International Health Regulations (2005)
3. Increasing access to essential, high-quality and affordable medical products
4. Achieving the health-related Millennium Development Goals and Sustainable Development Goals
5. Addressing the challenge of non-communicable diseases and mental health
6. Reducing health inequities by addressing social, economic and environmental determinants of health

The World Health Organization is financed by dues paid by Member States, voluntary contributions from Members States and partner organisations such as foundations and civil society and contributions from the private sector.\(^2\) The World Health Assembly is the decision-making body of WHO and determines the policies of the Organization, appoints the Director-General, supervises financial policies, and reviews and approves the proposed programme budget.\(^3\) The World Health Organization is currently undergoing a reform which includes the establishment of a new Health Emergencies Programme. The programme adds operational capabilities for outbreaks and humanitarian emergencies to the WHO’s traditional technical and normative role.\(^4\)
6.3 THE WESTERN PACIFIC REGIONAL OFFICE

The Western Pacific Region comprises approximately 1.8 billion people and stretches over a vast area, from China in the north and west, to New Zealand in the south, and French Polynesia in the east. The Western Pacific Region is one of the most diverse of the WHO region; it constitutes some of the world’s least developed countries as well as some of the most rapidly emerging economies. There are 37 countries and areas in the Western Pacific Region. The Western Pacific Region is vulnerable to health security and emergency risks brought about by disease outbreaks, emergencies and disasters. The Regional Office for the Western Pacific is located in Manila, the Philippines and represents WHO in the Asia Pacific. The Western Pacific Regional Office operates semi-autonomously with its own regional budget. The purpose of WPRO is to lead the regional response to public health issues towards achievement of WHO’s global health mission through research, data banking, evaluation, awareness raising and resource mobilisation.

6.4 INTRODUCTION TO EVENT-BASED SURVEILLANCE

Event-based surveillance (EBS) may be defined as the organised and rapid capture of information about events that are a potential risk to public health. Event-based surveillance is usually a passive process and involves the screening of a range of information sources, both official and unofficial, for events of potential public health concern and assessing these events for veracity and risk. The objective of EBS is to detect threats to public health before more traditional surveillance systems to allow prompt public health response and thus minimise morbidity, mortality and public health concern. For EBS to be successful, the system must be closely tied to the capacity to initiate and conduct a rapid public health response.

As opposed to EBS, indicator-based surveillance (IBS) involves the collection and analysis of structured data based on established surveillance and monitoring protocols tailored to each disease. Indicator-based surveillance systems often use statistical methods to compare observed versus expected rates of disease and thresholds to signal usual epidemiological patterns. For these reasons, IBS is not designed to detect rare, new or unexpected occurrences of disease and there is often a time lag between event date and signal detection which precludes a rapid response. Event-based surveillance should not replace IBS; rather it should supplement traditional surveillance systems. Both IBS and EBS should be seen as essential components of a single national surveillance system. Event-based surveillance is useful to rapidly detect rare and new events as well as events that occur in populations that do not or cannot access health care through formal channels. Event-based surveillance is relatively simple and inexpensive and is seen as an important tool for public health surveillance and response particularly in low-resource settings. Examples of the utility of EBS include the early detection of outbreaks of influenza H5N1 in the Western Pacific Region in 2004.
the strengthening of Ebola surveillance and response in Sierra Leone, and the rapid detection of infectious disease threats at mass gatherings such as the Olympic and Paralympic Games.

6.5 EVENT-BASED SURVEILLANCE AT THE WESTERN PACIFIC REGIONAL OFFICE

The WHO’s WPRO in Manila systematically conducts EBS for the Region. Event-based surveillance at a regional level provides an additional early warning system for all countries, particularly for diseases that can rapidly spread across the region. In this way, WPRO EBS strengthens regional systems and capacity for surveillance, risk assessment and response to acute public health events. Such capacity building aligns with the goals of the Asia Pacific Strategy for Emerging Diseases as well as the requirements of the International Health Regulations (IHR 2005).

At a time there may be up to three Rumour Surveillance Officers employed to conduct EBS on a daily basis, year-round. This role is usually filled by Field Epidemiology Training Program scholars from countries in the region. The EBS conducted at WPRO is designed to be sensitive and takes an all-hazards approach. The ESR Unit works closely with DRM and the Food Safety Unit to share information of events such as earthquakes and cyclones, and outbreaks associated with foodborne pathogens that may have important public health consequences. Rumour surveillance implies the monitoring of unofficial sources such as the media and social networking sites. Event-based surveillance at WPRO involves scanning of these unofficial sources as well as intelligence from official sources such as WHO headquarters, regional offices and countries offices, and Member States’ health departments.

On average, one Rumour Surveillance Officer scans 155 pieces of information per day and of these, ten events may be assessed as having potential risk to public health in the Region and are selected for follow-up. This risk assessment process is guided by questions contained Annex 2 of the IHR. Additional risk assessment questions used by Rumour Surveillance Officers focus on the capacity of the affected country to respond to the threat as well as the level of public health concern expected for the event. Public perception is a key factor in the EBS risk assessment process at WPRO as an important objective of this surveillance is to decrease the potential for misinformation, misunderstanding, fear and panic by disseminating correct information to the public. Information sharing within the WHO network is an important avenue for event notification, event verification, and collaborative risk assessment.

6.6 MY ROLE

As a Rumour Surveillance Officer, my role was to conduct EBS each morning. This process usually began around 0600 and involved scanning a range of different sources to detect events of potential
risk to public health in the Region. Several reliable sources were scanned in preference to other sources: the WPRO Outbreak inbox (emails from WHO network), the Global Public Health Intelligence Network (GPHIN), ProMED-mail, the Center for Infectious Disease Research and Policy (CIDRAP) website, and the FluTrackers.com website). The following 10 criteria were used in the risk assessment to select events of concern for follow-up:

1. An acute public health event of potential international public health concern
2. Unusual epidemiological characteristics (clinical picture, time, place, person, transmission) of a known disease
3. A disease caused by a novel or emerging pathogen
4. A cluster of cases or deaths with similar symptoms
5. An event be caused by a contaminated, commercially or widely available product (e.g. a food item, bottled water)
6. An event with possible consequences for trade or travel
7. Suspected or potential spread of the infection in a health care or mass gathering setting
8. An event with known or suspected consequence for human health (e.g. chemical spill, unexplained deaths in animals)
9. An event with the potential to cause public panic or concern

Follow-up involved recording key epidemiological details of each event (time, place, and person), the level of risk I assigned to the event and justification for this level. These details were presented to the ESR Unit at 0700 for discussion and a more formal risk assessment. For events that were considered by the ESR team to be a threat to public health and which may require further action, key details of the event were included in a Powerpoint presentation that was given by the Rumour Surveillance Officer to the wider DSE Unit including the Director in an 0830 meeting. It was important to develop a key risk assessment question(s) and assign a level of risk for the event in this presentation. In this meeting, the wider DSE Unit were given the opportunity to ask questions about the event, discuss the level of assigned risk and develop a response plan if action was required. It was essential that these presentations were concise and contained only relevant information. I took the lead in developing new Powerpoint slide templates that prompted Rumour Surveillance Officers to include necessary information. In the majority of cases, follow-up action consisted of sharing information of the event with the relevant representative in the WHO Country Office(s), requesting further information to inform the WPRO risk assessment and to determine whether further action is required. Also in the DSE meeting, updates were provided for continuing events. These updates included a list of the actions taken by WHO (Headquarters, Regional, Country), a list of proposed
actions as well as a revised risk assessment. In the action arm of EBS at WPRO, the Rumour Surveillance Officer was mainly assigned the task of contacting WHO Country Offices to notify or obtain further information.

Certain diseases were considered a high priority for the Region and were usually reported on in the morning meetings if reports were found. While I was at WPRO, such diseases included dengue, human infection with avian influenza viruses and Middle East Respiratory Syndrome (MERS) coronavirus. Due to the 2015 outbreak of MERS in the Republic of Korea, WPRO was on alert for any further indication of this disease in the Region. I will now give three examples of interesting events that were detected by, or monitored by, WPRO EBS during my stay.

The first was a notification through official channels of animals dying on a remote island of Yap State, Federated States of Micronesia. The report was of paralysis and deaths in chickens and dogs. No information regarding number of deaths, time period, or reports of unusual human disease was given in the initial notification. Due to my veterinary background, I was given the task of compiling a list of differential diagnoses, and providing a risk assessment of this event for human health. If chickens and dogs were dying of the same disease, it was my assessment that the event could be a potential risk to human health given the pathogen may have developed the capacity to cross species’ barriers. I decided that further information was needed to give an accurate assessment of the risk to public health. A request for information was sent via a WHO representative in Fiji to health officials in Yap State. Further information revealed that in addition to chickens and dogs, cats and rats had been found dead on the island since late November. A table of the number of deaths for each species was provided. No unusual human illness had been observed on the island. It was my assessment that this event was most likely due to toxicity rather than an infectious agent. I suggested that specimens be taken from ill or freshly deceased animals for laboratory testing. Due to the remoteness of the island, a veterinarian from Guam could only provide such a service once a month. At my suggestion, WPRO advised the veterinarian to take relevant personal protective equipment for sampling. Neither further reports of animal deaths nor unusual reports of human illness were received during my time at WPRO. We did not hear as to whether animal samples were taken.

The second event was a notification through the Pacific Public Health Surveillance Network (PPHSN) of numbers of cases of diarrhoeal illness above baseline in the Solomon Islands. The ESR Unit worked closely with the WHO Pacific Technical Support Division (DPS) to obtain more information and to provide epidemiological and technical support. This event was an outbreak of rotavirus in children affecting multiple islands. A number of deaths were attributed to this outbreak. Due to a lack of epidemiological expertise on the Island, an epidemiologist from DPS and an epidemiologist
from WPRO were deployed in the field. It was my role during this response to obtain weekly situation reports from the epidemiologists and to present the relevant information in the DSE morning meetings. Relevant information included the number of cases including deaths, geographical spread, public perception, and any ongoing support required in the field. The outbreak was ongoing after I left WPRO.

During my time at WPRO, the IHR (2005) Emergency Committee declared the cluster of microcephaly cases and other neurological disorders associated with Zika virus infection a Public Health Emergency of International Concern (PHEIC). The WPRO Emergency Operations Centre (EOC) was activated in response to this declaration which triggered an organised set of roles and responsibilities for DSE. I contributed to this response by conducting enhanced EBS for Zika virus in the Region, providing input into developing a risk assessment for the Region, preparing a set of talking points for the Regional Director, and providing input into technical presentations and material for DSE, WHO Country Offices and Member States. Enhanced EBS for Zika virus concentrated on measures of public perception of the event which was gauged by public activity on social media and by public health actions taken by countries in the Region (e.g. travel restrictions, advice to pregnant women, airport screening). With heightened public interest it was necessary for WPRO to disseminate accurate information and risk assessments in order to avoid public fear, panic and unsubstantiated public health actions taken by countries in the Region.

In addition to conducting EBS, the role of Rumour Surveillance Officer also involved preparing weekly and bi-weekly surveillance reports that were disseminated internally as well as to the public. This gave me experience in communicating epidemiological data to a lay audience. The weekly surveillance report was an epidemiological summary of human infections with avian influenza viruses in the Region. An example of this report that I prepared can be accessed at: http://www.wpro.who.int/emerging_diseases/ai_weekly_515_wpro_20160108.pdf?ua=1. The bi-weekly reports were epidemiological summaries of dengue, hand, foot and mouth disease, and seasonal influenza in the Region. An example of a seasonal influenza report that I prepared can be accessed at: http://www.wpro.who.int/emerging_diseases/influenza_biweekly_20151222.pdf?ua=1. Data used for these reports were obtained from a combination of WHO Country Offices, Member States’ health department websites (including Facebook), and the WHO Disease Outbreak News (DONs) webpage.

As a side-project, I took the lead in improving the database used by Rumour Surveillance Officers to record events detected through EBS. The existing ACCESS database had not been used for data entry for two months prior to my arrival. The main reason for the lack of acceptability was the time required
to complete the entries; too much information was requested, as well the database was not easy to use – there were many hidden tabs and extra boxes that made data entry laborious. There had been a number of requests from senior management regarding the sensitivity of the EBS system – specifically the number of events detected and the number of events resulting in action taken by WPRO. It was not easy to extract the data required to answer these questions from the existing database. It was my job to develop a database that contained only the essential fields necessary to evaluate EBS at WPRO and that was easy to use. I decided upon the essential fields, created a Microsoft Excel spreadsheet, and backfilled the database to 1 October 2015. Having over a years’ worth of data in the spreadsheet allowed me to conduct an evaluation of EBS at WPRO. A considerable amount of resources are invested into EBS at WPRO however the system has never been evaluated. I conducted the evaluation by developing indicators to assess the relevant attributes listed in the Updated Guidelines for Evaluating Public Health Surveillance Systems developed by the Centers for Disease Control and Prevention (CDC), Atlanta. The outcomes of this evaluation were presented to DSE in my final week at WPRO. A copy of this presentation can be found in Appendix 6-1. My main findings were that EBS at WPRO is a sensitive system with a low positive predictive value. While these attributes are in line with the objectives of the system, changes could be made to make surveillance more efficient by concentrating EBS on sources that present events more likely to result in public health action. The last time I contacted WPRO (March 2016), the revised database was being used by the Rumour Surveillance Officers.

6.7 LESSONS LEARNT

My time at WPRO was very rich in both professional and personal experiences. I learnt about the relationship that WHO has with Member States and how this relationship varies by country in terms of open avenues of information sharing. I learnt a lot about EBS, particularly when it is useful and where perhaps it is not so useful. At a regional level I am not convinced that EBS is particularly capable of detecting the onset of events before detection by the affected country. I see the major role of EBS at WPRO is in information sharing. Once an event is detected through EBS, it gives WPRO the opportunity to open up lines of communication with the affected country and then through the WHO network. This enables the provision of assistance if requested from the affected country. My experience highlighted to me the importance of risk assessment and response capacity to EBS; EBS is useless without these two components. Another use for EBS at a Regional level is in assessing the level of public health concern about an event and sharing this information with affected countries, particularly if they don’t have the capacity to monitor social media. I presented my WPRO experience at the MAE turns 25 celebration day on 14 September 2016 as part of the 2016 Australasian Epidemiological Association’s 23rd Annual Scientific Meeting at the Australian National University.
in Canberra. My oral presentation was titled ‘Does rumour surveillance work?’ A copy of this presentation is included in Appendix 6-2.

### 6.8 PUBLIC HEALTH IMPORTANCE

In the future, regional surveillance at WPRO will move away from traditional indicator-based surveillance and towards event-based surveillance. Particularly as many countries in the Western Pacific do not have robust surveillance systems or the capacity to conduct routine surveillance, EBS at WPRO provides a relatively inexpensive and flexible means to strengthen disease surveillance in the Region. My initial evaluation of the system hopefully highlighted to DSE the importance of regular system evaluations to continually improve how EBS is conducted and how data are recorded. A future opportunity for WPRO EBS will be the systematic inclusion of the scanning of social media sites into the surveillance conducted by Rumour Surveillance Officers. Currently social media scanning is done on an ad-hoc basis. Scanning social media provides an opportunity to detect events occurring in real-time and also adds to information on public perception. There would need to be procedures developed relating to the mining of vast amounts of information and to the assessment of veracity if social media scanning was routinely included in WPRO EBS.

### 6.9 REFERENCES


Event-based surveillance (EBS)

What is EBS?

“Event-based surveillance is the organized and rapid capture of information about events that are a potential risk to public health”

Objectives of EBS

1. To rapidly detect events that pose a risk to public health in the region
2. Provide a mechanism through which rare and new events that are not captured by indicator-based surveillance are detected
3. To effectively respond to an event to minimize public health impact

Are these objectives being achieved?
Evaluation WPRO EBS

- No previous evaluation of WPRO EBS
- No documented procedure to evaluate WPRO EBS
- Key tool for evaluation would be the EBS database (DB), however:
  - No clear objectives
  - No clear documentation for what should be included
  - Inconsistent use
  - Many fields
  - Usability low

Evaluation WPRO EBS

- My tasks:
  1. Develop a plan for EBS evaluation
  2. Develop indicators for EBS evaluation
  3. Develop objectives for database
  4. Improve current database with essential fields required for evaluation and documentation of steps of triangle
  5. Initial evaluation (1 October 2015 to 31 January 2016)
Important attributes EBS

1. **TIMELINESS** – time from event onset to WHO detection and time from WHO detection to response must be as short as possible
2. **SENSITIVITY** – must minimize number of events of public health concern that are not detected (false negatives)
3. **RESPONSE** – communication for action
4. **USEFULNESS** – improve capacity for event detection in WPR
5. **REPRESENTATIVENESS** – the probability of event detection should be the same for each country
6. **PREDICTIVE VALUE POSITIVE** – system should be efficient and a good use of resources

WPRO EBS Database

- **Objectives**
  - To capture the outputs of the ESR team’s daily EBS
  - To provide a source of information to evaluate the effectiveness of WPRO EBS

Number of reports screened (bottom layer)

A screened event  
= Any information that is read/eye-balled and rapidly assessed for risk
Number of reports screened (bottom layer)

Week ending 29 January 2016

- 774 reports screened (average) per surveillance officer
- Daily average of 155 reports per surveillance officer
- Data recorded in separate tab in DB

Number of new events detected (2nd layer)

- Only new events entered into DB
- Definition ‘new’ difficult

Number of new events detected (2nd layer)

A new event:
1. An event discussed in the pre-MM AND
2. An event that has not been recorded previously unless there is information that changes level of risk AND
3. An event that has a direct or indirect impact on WPR public health AND
Number of new events detected (2nd layer)

4. An event that meets one or more of the following criteria:
   I. An acute public health event of potential international public health concern
   II. Unusual epidemiological characteristics (clinical picture, time, place, person, transmission) of a known disease
   III. A disease caused by a novel or emerging pathogen
   IV. A cluster of cases or deaths with similar symptoms
   V. An event caused by a contaminated, commercially available product (e.g., a food item, bottled water)
   VI. An event with possible consequences for trade or travel
   VII. Suspected or potential spread of the infection in a health care or mass gathering setting
   VIII. An event with known or suspected consequence for human health (e.g., chemical spill, unexplained deaths in animals)
   IX. A potential for the event to cause public panic or concern
   X. An event with the potential to cause public panic or concern

Number of new events detected

- 239 entries (total)
- Per day: median 3 events, range [1 to 10]

Number of new events detected

- Day of week most common for new event detection
Number of new events detected

Number of events detected by hazard
(1 Oct 15 to 31 Jan 16)

Will concentrate on infectious disease from here on in...

Number of new events detected
(1 Oct 2015 to 31 Jan 2016)

• by Agent:
  – Over 50% due to dengue, avian influenza and MERS-CoV

Number of new events detected
(1 Oct 2015 to 31 Jan 2016)

• by Affected Country:
  – Following countries accounted for > 60% events:
    • 17% Taiwan, China
    • 14% China (mainland)
    • 11% Hong Kong
    • 9% Viet Nam
    • 8% Australia
    • 5% Malaysia
  – 6% Non-WPRO
  – 4 events with 2 affected countries
Number of new events detected
(1 Oct 2015 to 31 Jan 2016)

- by Affected Country AND most common Agent:
  - Taiwan, China
    - 92% Dengue
  - China (mainland)
    - 66% human infection avian influenza
  - Hong Kong
    - 38% MERS-CoV
  - Vietnam
    - 47% Dengue
  - Australia
    - 35% Pertussis
  - Malaysia
    - 55% Dengue

- Non-WPRO
  - MERS-CoV (67%), Zika virus (17%), Ebola virus (8%), Dengue (8%)

Source
(1 Oct 2015 to 31 Jan 2016)

Evaluation – Response and PPV

Definitions:
- Alert:
  - The process of WPRO informing WHO, other responsible bodies of the event
  - WPRO is the source of information
  - Does not include dissemination of technical advice
  - Does not include sharing of information within WPRO

- Action:
  - A step that is taken which directly improves the management of the event to minimize impact upon public health
  - Includes:
    - Conferences with responsible bodies to form a risk assessment
    - Provision of technical assistance/support (including support for ES mapping)
    - Deployment of staff to the field
    - Provision of supplies and equipment
    - Funding for management/monitoring of the event
  - Does not include:
    - An alert (above)
    - Contacting a responsible body for further information about the event
Evaluation – Response and PPV

• Indicators:
  1. Number of events that resulted in an alert [Response]
  2. Number of events that resulted in action [Response]
  3. Proportion of events that resulted in action [PPV]

Evaluation – Response and PPV
(1 Oct 2015 to 31 Jan 2016)

Indicators:
  1. Number of events that resulted in an alert [Response]

18 of 213 events
(8%)
Evaluation - Timeliness

- Indicators:
  1. Time from event onset to event detection by WPRO
  2. Time from event onset to response [Alert and/or Action]
  3. Time from WPRO event detection to response [Alert and/or Action]

- Event onset = earliest date of possible detection (e.g. onset of disease symptoms/deaths)
- Event detection = date of presentation of event in pre-MM by surveillance officer

Evaluation – Timeliness
(1 Oct 2015 to 31 Jan 2016)

- Indicator 1:
  - Time from event onset to event detection by WPRO

- For 112 events where date of event onset and date of WPRO detection recorded:
  - Median: 10 days
  - Range: 0 to 1,123 days (~3 years)
Evaluation – Timeliness (Indicator 1)

Average time lag (days) between event onset and detection by WPPO ESS by Affected Country

Evaluation – Timeliness (Indicator 1)

Average time lag (days) between event onset and detection by WPPO ESS by Agent

Evaluation – Timeliness (Indicator 1)

Average time lag (days) between event onset and detection by WPPO ESS by Initial Source of Information
Evaluation – Timeliness (Indicator 2)
(1 Oct 2015 to 31 Jan 2016)

- **Indicator 2 and 3:**
  1. Time from event onset to response [Alert and/or Action]
  2. Time from WPRO event detection to response [Alert and/or Action]

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**Evaluation**

- **Representativeness**
  - Not done
  - Proposed indicator:
    - Number of events per country/100,000 country population

- **Sensitivity**
  - Not done
  - Proposed indicators:
    - Number of events monitored by WCO that are not detected through WPRO EBS
    - Number of WPR events that appear in ES/DON that are not detected through WPRO EBS

- **Usefulness**
  - Not done
  - Proposed indicator:
    - Number of events that resulted in action that were detected first by WPRO EBS
      (period from event onset to event detection is smaller for WPRO than WCO)

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Regional Risk Assessment (3rd layer)
(1 Oct 2015 to 31 Jan 2016)

= An event presented at 8am morning meeting

- 44 of 213 new events presented at morning meeting
- Range [0-3] new events presented per day
Conclusions

- Sensitive system
- Low PPV
- This is in line with objectives of the system (sensitivity more important than specificity)
- But, could make surveillance more efficient (prioritize sources that present events more likely to result in action)

Future actions

- Finalise definitions
- Need to coordinate with DRM about inclusion of DRM events
- Build event entry and evaluation into daily surveillance officer routine:
  - Develop SOPs for EBS: Database and Evaluation
  - Link to more comprehensive event information (folders in Outbreak Inbox, One-Note (Hasrina)
  - Denominator of pyramid
    - Recommend recording events screened each day for a week, one week per month
    - Recommend quarterly evaluation of EBS
  - Analyse data in EBS against indicators
    - Cross-check information with WHO and HQ for sensitivity and timeliness analysis
    - Big picture: Web-based automation of data entry and presentation/reports

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Does rumour surveillance work?

Amy Burroughs
MAE Scholar, 2015-2016

Field placement: Australian Government Department of Health

Supervisors: Kathryn Glass, Martyn Kirk and Cindy Toms
Outline

- Introduction to rumour surveillance
- Does rumour surveillance work?
- Scenario

What is rumour surveillance?

“Event-based surveillance is the organized and rapid capture of information about events that are a potential risk to public health”
The process

Scanning  Risk Assessment  Verification  Action

Does rumour surveillance work?

It depends on...
1. Surveillance objectives
2. Intelligence sources
3. Expertise of surveillance officer
4. Informed risk assessment
5. Ability to verify
6. Ability to respond/influence a response
1. Surveillance objectives

- Mass gathering events
- Case finding during outbreaks/emergencies
- Correct misinformation and misunderstanding
- Local vs. national vs. regional vs. global
- Specific vs. all-hazards
- Minimize public health impact

2. Intelligence sources

<table>
<thead>
<tr>
<th>Unofficial</th>
<th>Official</th>
</tr>
</thead>
<tbody>
<tr>
<td>News media (newspaper, radio, television)</td>
<td>Health departments</td>
</tr>
<tr>
<td>Social media (Facebook, Twitter)</td>
<td>Laboratory networks</td>
</tr>
<tr>
<td>Electronic surveillance systems (e.g. GPHIN, ProMED)</td>
<td>Health workers/officers</td>
</tr>
<tr>
<td>Public</td>
<td>WHO network</td>
</tr>
</tbody>
</table>
3. Expertise of surveillance officer

- Frameworks for event selection
- Ideally an un-biased eye
- Information bias

4. Informed risk assessment

- Country context
- Public perception
5. Ability to verify

Scanning  |  Risk Assessment  |  Verification  |  Action
6. Ability to respond/influence a response

- Scanning
- Risk Assessment
- Verification
- Action
Summary

<table>
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<th>Success Factor</th>
<th>Achieved?</th>
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<td>System objectives</td>
<td>Identified an event of potential public health concern</td>
</tr>
<tr>
<td>Intelligence sources</td>
<td>Through official channels</td>
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<tr>
<td>Expertise of surveillance officer</td>
<td>Importance of One-Health</td>
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<tr>
<td>Informed risk assessment</td>
<td>Gathered more information</td>
</tr>
<tr>
<td>Verification of the event</td>
<td>Established and receptive network</td>
</tr>
<tr>
<td>Ability to respond/influence a response</td>
<td>Not required</td>
</tr>
</tbody>
</table>

Acknowledgements

ANU: Martyn Kirk, Kathryn Glass

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WPRO: Tackuya Yamagishi, May Chiew, Yoshihiro Fujiya, Babatunde Olowokure, Ailan Li, Jo Fuellas, Katie Russell, Hasrina Hassan, Mizue Kanai, Tuya Ochirpurev
CHAPTER 7  TEACHING

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Appendices

Appendix 7-1 Lesson from the field ...................................................... 184
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7.1 LESSONS FROM THE FIELD

The MAE Lessons from the Field (LFF) give students the opportunity to share key learnings from their projects with the rest of the cohort, particularly topics that may not have been covered in course block. There are two components to the LFF series. The first is to conduct an LFF which involves developing a lesson, administering the lesson to your peers and then providing feedback on answers at a teleconference. The second is to participate in the LFFs of your peers.

7.1.1 Trend analysis and interpretation

My data analysis project (Chapter 2) involved the interpretation of trends in notification rates of syphilis over a 10 year period. Assessing trends in disease data is commonplace in epidemiological practice. There are many ways to assess trends, both descriptive and statistical, and the appropriate method to choose really depends on the research question you are asking. For the data analysis project, I could have compared the first year of the period to the last year of the period but this would have missed information in the middle and if either of these years were unusual (e.g. change in case definition) then comparing them may not have been appropriate. I also could have only looked at the most recent two years of data to assess current trends which may have been appropriate to address progress towards syphilis elimination targets. The objective of my LFF was to document and describe common methods of assessing trends in disease data, to describe scenarios where certain methods are most appropriate and to discuss any limitations of using each method. I conducted the LFF on 9 August 2016 and the lesson with answers is included in Appendix 7-1.

7.1.2 Participation in LFF

I participated in six LFFs during my placement. These included:

- Foodborne outbreak investigations: Estimating incubation periods and exposure times (Anthony Draper)
- Basic analysis on hospital data (Cecilia Xu)
- Using postcodes to assign place of residence within Australia, and create new variables based on historical targeted funding of the hepatitis A vaccine under the National Immunisation Program (Craig Thompson)
- Logic models (Samantha Siripol)
- Introduction to pharmacovigilance (Paul Dutton)
- Principal component analysis (Alex Marmor)

Students put a great deal of effort into making their lessons informative and applicable. I used Stata coding commands given in Cecilia and Craig’s LFF to help with my analysis of hospital data in Chapter 4.
7.2 TEACHING EXERCISE FOR MAE COHORT 2016

During semester one course-block in March 2016, the MAE cohort of 2015 (second years) conducted a half day training session for the MAE cohort of 2016 (first years). This teaching session aimed to provide the first years with knowledge and practical experience in three major epidemiological concepts. The session concluded with a presentation by Craig Thompson on the top tips for surviving the MAE. Each student provided their one tip to share with the first years. Mine was ‘always refer back to your research questions.’

Three groups developed 20-30 minute sessions on the following topics:

- Study types – Johanna Dups, Paul Dutton and Cecilia Xu
- Confounding – Samantha Siripol, Alex Marmor, Amy Burroughs and Darren Westphal
- Administering questionnaires in outbreak investigations – Anthony Draper, Tanyth de Gooyer, Jana Lai, Alicia Arnott, Tambri Housen and Craig Thompson

Our group developed a 20 minute session that aimed to clarify the concept of confounding by presenting different explanations. There was a moment a few of us remembered in Semester 2 2015 course-block where the concept of confounding suddenly made more sense. This was when it was explained to us that the ‘confounder’ is usually the actual risk factor for disease and due to this ‘true’ relationship with the outcome, it can create spurious relationships between other ‘red-herring’ risk factors and the outcome simply through the association of the confounder and the ‘red-herring.’ Our session began by grabbing the students’ attention with a skit. It was a murder mystery scene with a dead body (‘outcome’) an implicated suspect (‘red herring’) and the murderer (‘exposure’). After the scenario we gave the students a Powerpoint presentation to explain confounding and why it is important to consider. In addition to the skit, we used a different schema to explain the relationship of the confounder, the spurious exposure and the outcome – this was a ‘water-pipe’ model that we found in the literature. We hoped that by explaining the concept in various ways we would maximize the number of students that would also have an ‘ah-ha!’ moment.

We obtained good feedback for our presentation on confounding. Feedback surveys were given to the audience and we were graded out of five for six attributes. We received an average grade of 4.4 for content, 4.6 for instructor presentation, 4.7 for methods, 4.4 for learnt something new, 4.6 for engagement and 4.6 for asking questions. Some general comments from students are below:

- Enjoyed the balance between interactive and didactic learning
- Thought the session was fun no need to improve
- The case study/skit with the murder victim was great! Loved the pipes example as well
• Session was great. Don't be afraid to go out into deeper detail though, I think we would have coped
• Perhaps some more examples and ones that are a bit trickier to define, in case we come across such things

We could have improved by explaining some more complex examples of the effects of confounders. It is difficult to get the right balance between wanting the audience to understand a concept and also challenging those who already have a good grasp of the subject. A copy of the Powerpoint presentation is given in Appendix 7-2.

7.3 APPENDICES

Appendix 7-1 Lesson from the field

Lesson from the field

Amy Burroughs – August 2016

Trend analysis and interpretation

This lesson from the field (LFF) is a self-directed learning exercise and will be emailed to participants on Friday 29 July 2016 along with teleconference invitation and dial-in details.

Participants are asked to complete the questions and email your answers to: amy.burroughs@health.gov.au by close of business 5 August 2016. A teleconference will be held at 3pm AEST on Tuesday 9 August 2016 to review answers and address any problems.

If you encounter any problems with this LFF, please contact me by email or phone: 0262893354. Thanks and hope you find it worthwhile.

Instructions

• This LFF requires you to:
  o Use Microsoft Excel and Stata
  o Read the two articles provided; concentrating on the methods used to quantify trends in rates over time
  o Answer the following 14 questions

Learning objectives

After completing this LFF participants should be able to:

• Identify where trend analysis may be useful to interpret epidemiology data
• Apply various statistical methods to quantify trends in rates over time
• Interpret the outputs of each statistical method
• Understand the limitations of each statistical method
Introduction

Trend analysis is a cornerstone of epidemiology. Epidemiologists have a long tradition of monitoring trends in rates of disease and death and trends in medical, social, and behavioural risk factors that may contribute to these adverse events.

Question 1: List some general reasons why you may want to assess trends in a disease over time

- Determine if disease is becoming more or less common
- Evaluate the effect of an intervention (assess period of time before vs. after an intervention)
- To target interventions/resources to specific populations who have a rising trend
- Permit predictions about future rates of occurrence
- Examine whether the disease may be becoming more/less frequent in particular age groups, sex, Indigenous status, area, etc. (identify high risk groups)
- To detect outbreaks
- If disease is targeted for elimination, evaluate progress towards elimination
- Influence policy (provide evidence)
- Estimate what is the normal rate in the community (“baselines”)
- Determine seasonality of disease

A series of conceptual issues must be addressed before analysing and interpreting trend data. These issues include:

1. **Sample size** – the number of time periods being examined
2. **Presence of extreme observations or outliers**
3. **Availability of numerator and denominator data**
4. **Confounding** – changes over time in factors related to the indicator of interest

**Sample size**

In public health, trend analysis is typically carried out at the ecologic level. That is, the observations, of units of analysis, are time periods (years, months, days) and not individuals. For a dataset containing records by year over a 16 year period, there are 16 observations, one for each year. In statistical terms, these 16 observations are a sample in time, and therefore 16 is the sample size for analysis regardless of the size of the population denominators. The fewer the number of time periods available, the smaller the sample size and the greater the potential for error. The longer the time period, the more information and therefore the more likely it is to precisely identify patterns of change.

**Presence of extreme observations**

Another consideration when analysing and interpreting trends over time is whether there are extreme observations, or outliers, in the data. If there are, it is important to determine whether these are due to random variability or whether they reflect a real departure from the general trend.
Availability of numerator and denominator data

The accuracy of numerator and denominator information over time is also very important in insuring meaningful interpretation of trend data. Some indicators will require population denominators which are not collected regularly or may not be collected accurately (e.g. highly mobile populations, Aboriginal and Torres Strait Islander persons, men who have sex with men).

Confounding

Changes over time in factors related to the indicator of interest must be considered. For example, change in the socio-demographic characteristics of the population (e.g. age structure, ethnic composition) may be associated with the change over time in the indicator that is of primary interest. Is comparing the health status of a community from 1970 to 1995 meaningful? Is it really the “same” community at the two endpoints of the trend analysis? In addition, changes in case definitions, reporting accuracy, and testing rates over time may confound the trend information and lead to misinterpretation.

Scenario:

As a surveillance officer on an island in the Pacific, you are required to analyse and interpret trends in the number of babies born with microcephaly over the last 16 years (2000-2015). You are provided with a spreadsheet of the number of microcephaly cases reported, the number of live births and the rate of microcephaly per 1,000 live births; per year (csv file attached). The following analysis will concentrate of the rate of microcephaly per 1,000 live births.

Instruction 1: Open csv file ‘microcephaly data’ in Excel or Stata and graph the rate of microcephaly per 1,000 live births by year

Question 2: Give a general description of the trend in the rate of microcephaly on your island (no calculations required, just a general description)

- Rate remained below 20 cases of microcephaly per 1,000 live births from 2000 to 2012
- From 2012 to 2015, rate increased rapidly, from 25 to 165 cases per 1,000 live births
- Slight increases have also occurred for years 2005 and 2008
Question 3: Considering the 4 conceptual issues described above, what factors apart from an increase in disease prevalence may be influencing the trend?

- Remote Island – denominator data may not be recorded well
- Case definition changed
- Increased awareness (more likely to screen, detect)
- More sensitive diagnostic test (with awareness of Zika, new diagnostic tools)
- You’ve just captured part of the longer-term variability in the trend (i.e., small sample size)
- Change in the reporting requirement, from voluntary to mandatory
- Quality of record keeping in 2000 compared to 2015 (e.g., better registration of births)
- Change in the community population structure, e.g., more young women at childbirth age

Methods to quantify trends

1. Comparing the rate at the start to the rate at the end of the study period
2. Comparing the rate of the second last year to the rate of the last year
3. Average yearly change (%)
4. Test for linear trend (Stata)
5. Poisson regression (Stata)

Question 4: Calculate the % change in the rate of microcephaly, comparing 2000 to 2015

- There is an increase in the rate of microcephaly of 1481% from 2000 to 2015
- \[ \frac{165.24 - 10.45}{10.45} \times 100 \]
Question 5: What issues to you see in using this method? What information may be lost?

- Losing information about what is happening in between (may have gone up and down).
- First and last years may have been usual for a number of reasons.
- Does show how steep the change is from 2012 to 2015, not sure if this is a gradual change or a steep change over a small number of years.
- Omits that the issue started 2011 / 2012

Question 6: Calculate the % change in the rate of microcephaly, comparing 2014 to 2015

- There is an increase in the rate of microcephaly of 24% from 2014 to 2015
- \( \frac{(165.24-132.82)}{132.82} \times 100 \)

Question 7: What issues to you see in using this method? What information may be lost?

- Losing information about what is happening in years before – are last two years unusual?
- Small changes in numbers give large % changes

Question 8: Where may this type of analysis be appropriate?

- Program targets
- Recent progress towards a goal (e.g. elimination)
- When not concerned with historical numbers
- If there was a problem with the previous years’ data (ie an artefact) – quality unreliable/collection method changed
- Useful if there was an intervention introduced during 2014 and you wanted to investigate its influence on the rate of microcephaly the following year (e.g. vaccine)
Question 9: Calculate the average yearly % change in the rate of microcephaly across the study period (calculate % change from year to year, sum all % changes then average). This method is what was used in the Barros et al. (2010) article provided.

- There is an average yearly % change (increase) of 38%

Question 10: What are the pros and cons of using this method in your analysis?

- Pros:
  - It accounts for the change across all years, uses all available data

- Cons:
  - Shows average, not ups and downs and rates of change.
  - Some of the clearly non-linear trends in the Ward paper (e.g., remote/very remote Indigenous Australians in Figure 4) are good examples of where this can be dodgy.
  - Using % changes with small numbers can give large % changes.

Note: Using % changes with for a disease with small numbers of notifications may be dangerous – small changes in numbers of notifications (e.g. 1 to 2 cases) give large % changes.

Instruction 2: Import the csv file ‘microcephaly data’ into Stata.

The next analysis will assess the significance of any linear change in the rate over time and the years during which the linear change occurred. That is, did the rate increase, decrease, or stay the same? At least two years of data are required to test for a linear change. A significant linear change indicates that the rate either significantly increased or decreased linearly over time. The following 3 graphs show trends with a significant linear change:

The following 4 graphs show trends with a non-significant linear change:

A test for linear trend in Stata is `nptrend`
Question 11: Enter the command nptrend rate, by(year). What is the p-value and what is your interpretation of this result?

- P-value = 0.002
- There is a significant increasing linear trend in the rate of microcephaly over time

<table>
<thead>
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<th>year</th>
<th>score</th>
<th>obs</th>
<th>sum of rank</th>
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<tbody>
<tr>
<td>2000</td>
<td>2000</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2001</td>
<td>2001</td>
<td>1</td>
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<tr>
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<td>2015</td>
<td>1</td>
<td>16</td>
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</table>

Instruction 3: Enter the command:

**poisson cases microcephaly year, exp(livebirths) irr**

This command performs a Poisson regression analysis of the rate of microcephaly with time. This is the same as the analysis used by Ward et al. (2001) in the article attached. As we are using count data, we use a Poisson analysis. And, as we are analysing rates, this command factors in population denominator data. The irr command at the end will give us an Incidence Rate Ratio. We are not using ‘i.’ in Stata – we don’t want separate IRR’s for each year, we want an overall IRR for the variable year (year in this analysis is treated as a continuous rather than a categorical variable). Using year as a continuous variable, we will measure the overall trend.
Question 12: What is the IRR, p-value and 95% confidence interval? How would you put this result into words?

- IRR of 1.31 = over the 2000-2015 period, from year to year there was an average 31% increase in rate of microcephaly. Annual trend. IRR is significant.

- NOT an average annualised rate – IRR is not reporting a rate of microcephaly per 1,000 live births, reporting a change in rate. Not averaging anything.

```
. poisson casesmicrocephaly year, exp(livebirths) irr
Iteration 0:  log likelihood = -190.22424
Iteration 1:  log likelihood = -189.51058
Iteration 2:  log likelihood = -189.50968
Iteration 3:  log likelihood = -189.50968

Poisson regression                       Number of obs =     16
                                            LR chi2(1) =   1233.50
                                            Prob > chi2 =  0.0000
Log likelihood = -189.50968             Pseudo R2 =  0.7650

casesmicrocephaly | IRR   Std. Err.     z     P>|z|    [95% Conf. Interval]
-------------------+----------------------------------------
          year     | 1.313625   .0123809  28.94   0.000   1.289582  1.338116
     _cons      | 2.4e-240   4.6e-239  -29.09   0.000   1.7e-256  3.4e-224
ln(livebirths)   | 1 (exposure)
```

```
Iteration 3:  log likelihood = -189.50968
```

```
Iteration 2:  log likelihood = -189.50968
```

```
Iteration 1:  log likelihood = -189.51058
```

```
Iteration 0:  log likelihood = -190.22424
```

```
```

Log likelihood = -189.50968
```
Question 13: Compare your answer in Question 12 to your answer in Question 9. Why do they differ?

NOT 100% SURE OF ANSWER: THOUGHTS:

- Something to do with outliers having more weight in the first method?

- I think that is because in the analysis, Question 12 treated year as a continuous variable, while the one used in Question 9 was comparing each year with its previous year, instead of comparing with the trend/previous years? Also, the result in Question 12 tested if the trend is statistically significant or not.

- One is an average and one compares the fit of the data to the Poisson distribution????!!??!

- Poisson analysis does not assume that the count data is normally distributed (????)

Question 14: Looking at your graph, which method, if any, best describes the trend in the rate of microcephaly that you see? Would you use a different approach in your description?

- I’d do two analyses comparing the periods before and after 2012 when the rate inflects. Of the other methods, I think the percentage change over the whole period (q4) gives the best indication of the magnitude of the increase, if not the timing

- Both the “number” based methods are still quite crude, so I’d probably use a combination of one of these and a graph

- The growth rate is not really linear growth. Maybe try a non-linear regression analysis. Transform the data (log, natural log)

- I might look at describing the change in trends in 5 years blocks rather than across the whole 15 year period from 2000 – 2-15. You might look at ‘rolling’ 5 year rate changes over time.
Summary

- It’s important to first visualise what’s happening with a graph
- The method you use to assess trend really depends on your research question and what you want to describe
- There are many methods out there to quantify trends – from simple to complex
- Could use a combination of methods to describe trends
- If there is an obvious point in time where the slopes of the rates change, an ‘inflection point’ (e.g. before and after an intervention), then you could divide the years into two time periods and do separate tests for trends on each
- For data with inflection point(s), there is a software package called ‘Joinpoint’ which tests that the apparent change in trend is statistically significant. If you are interested you can find the software and more information at: https://surveillance.cancer.gov/Joinpoint/
- There is another method commonly used to assess linear trends – a chi-squared test for trend. If you are interested, a calculator can be found at: http://epitools.ausvet.com.au/content.php?page=trend

Thanks for your participation and I hope this gives you some simple tools to assess trends in epi data.
Appendix 7-2 Confounding presentation to 2016 cohort

Outline

• Why is confounding so.. Confounding? - Sam
• What is confounding? (quick recap) – Amy
• Poppers example – traditional “triangle” model – Alex
• Mumps/Zika examples – “water pipes” model – Darren
• Solving the mystery – interactive approach – “your turn” - All

What this session is... and isn’t

It is:
• to share with you our “a-ha” moment about what a confounder is
• to present different ways to conceptualise what a confounder is

It isn’t:
• a repeat of this morning’s lecture
Why is confounding so.... Confounding?

(Hopefully it’s not as much after we’ve described it though...)

con-found (kən-fənd’, kən-) v. To cause to become confused or perplexed. See Synonyms at puzzle.

v. To fail to distinguish; mix up: confound fiction and fact.

v. To make (something bad) worse: Do not confound the problem by losing your temper.

More at Wordnik  from The American Heritage® Dictionary of the English Language, 4th Edition
Learning objectives

• To define the relationship between a confounder and an outcome
• To differentiate a ‘red herring’ and a confounder
• To apply this understanding to examples

• What is your understanding of confounding?

• Why is confounding important in epidemiology?

• What are some methods we can use to control for confounding?
May 1982...

- Case-control study published in the Lancet:
- Cases: 20 homosexual men with Kaposi’s sarcoma
- 40 homosexual controls
  - matched for race and age

Results of Multiple Logistic Regression

<table>
<thead>
<tr>
<th>Exposure</th>
<th>RR</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent use of amyl nitrate*</td>
<td>12.3</td>
<td>4.2 – 35.8</td>
<td>0.002</td>
</tr>
<tr>
<td>10 sexual partners per month</td>
<td>2.0</td>
<td>1.3 – 3.1</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* Dose response relationship demonstrated in univariate analysis
Amyl Nitrate – “Poppers”

- often used as a club drug or to enhance a sexual experience
- facilitates anal intercourse by relaxing the internal and external anal sphincter muscles

Hypothesis

Use of Poppers \(\xrightarrow{\text{immunosuppression}}\) Kaposis Sarcoma
But...

- Throughout 1982 a new immune deficiency syndrome became apparent
  - primarily gay men, haemophiliacs and IDUs

- HIV virus identified 1983

HIV/AIDS was the confounder
Explaining confounding: “water pipes” model

Water pipes model

Confounder
Exposure and outcome share a common parent

Exposure
Outcome
Solving the mystery

if the confounder is blocked, the exposure-disease relationship becomes clearer...