Applied Epidemiology of Infectious Diseases in Western Australia

For the degree of

Master of Philosophy
(Applied Epidemiology)

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Department of Health Western Australia
DECLARATION OF WORK

This thesis is comprised of multiple discrete projects that have been undertaken collaboratively with multiple stakeholders. I acknowledge the contribution made by each of the stakeholders involved in the projects.

Taken as a whole document, I certify that this thesis is an original work. None of the work has been previously submitted by me for the purpose of obtaining a degree or diploma in any university or other tertiary education institution.

To the best of my knowledge, this thesis does not contain material previously published by another person, except where due reference has been made in the text. I acknowledge that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

Anita Catherine Williams
“It takes a village to raise a child” – African proverb

Whilst this may not be an actual child, my blood, sweat and many tears have gone into the work of my Master's degree and producing this thesis. Along with my own personal labours, the efforts, encouragements, criticisms, praises, comforts, anger and laughter of numerous others have provided the stimulus for this work. The list below is in no particular order of my gratitude.

I thank you all from the bottom of my heart.

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Professor Thomas V Riley, Dr Paul Armstrong, A/Prof Martyn Kirk

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Dr Niki Foster, Dr Claudia Slimings, Stacey Hong, Deirdre Collins, Dr Peter Moono, Pim Putsathit, Alan McGovern, Dan Knight, Christine Duncan, Dr Kate Hammer, Nikki Mann, Dr Briony Elliot, Dr Kerry Carson, Grace Androga, Su Chen Lim, Dr Yuan Wu

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Rina, Nick, Lauren, Daniel, Lachlan and Grace Williams, Catherine Ostojic, Kara Imbrogno, James Landes, Erica Hodgson, Anna-Lena Arnold, Alice and Lionel Wirth, Dario Alejandro, Joel and Dr Belinda Ramirez, Janet Bowman, Darren and Janelle Hultgren, Debbie Lewis, Hannah McArthur, Jon Shepherd, Jono Broughton, Dennis and Jeanette Preston, Josh and Aleisha van Bruchem, Ash and Mel Fenn, Keara and Adam Lendich, Bridget and Nathan Johnson, Wikus and Elbie Viljoen, Jen Gouvignon, Cath Loreck, members of C3 Crawley Church, the members of “por que no los dos” and the UWA PSA, and of course, ManCat.

My final thanks go to God, for without Him I could not have done this.
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Chapter 1

Introduction and Summary of Activities
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<table>
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<tr>
<th>Acronym</th>
<th>Full Text</th>
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<tbody>
<tr>
<td>ACIPC</td>
<td>Australasian College of Infection Prevention and Control</td>
</tr>
<tr>
<td>AQIS</td>
<td>Australian Quarantine and Inspection Service</td>
</tr>
<tr>
<td>BFV</td>
<td>Barmah Forest virus</td>
</tr>
<tr>
<td>CA-MRSA</td>
<td>Community-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>CDCD</td>
<td>Communicable Disease Control Directorate</td>
</tr>
<tr>
<td>CDNA</td>
<td>Communicable Disease Network of Australia</td>
</tr>
<tr>
<td>HAIU</td>
<td>Healthcare Associated Infection Unit</td>
</tr>
<tr>
<td>HISWA</td>
<td>Healthcare Infection Surveillance Western Australia</td>
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<tr>
<td>NATA</td>
<td>National Association of Testing Authorities, Australia</td>
</tr>
<tr>
<td>NCEPH</td>
<td>National Centre for Epidemiology and Population Health</td>
</tr>
<tr>
<td>PSA</td>
<td>Postgraduate Student Association</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>UWA</td>
<td>The University of Western Australia</td>
</tr>
<tr>
<td>WAMRO EAG</td>
<td>Western Australia Multi-Resistant Organism Expert Advisory Group</td>
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## 1. CHAPTER OVERVIEW AND REQUIREMENTS

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<td>Evaluation of the Healthcare Infection Surveillance Western Australia system</td>
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<td>Chapter 4</td>
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<td>Investigate an acute public health problem or threat&lt;br&gt;Analysis of public health data</td>
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2. ACTIVITIES

2.1 PRESENTATIONS

2.1.1 NATIONAL CONFERENCES


2.1.2 DEPARTMENTAL/INSTITUTIONAL SEMINARS

- UWA Bacteriology Research Group Seminar, October 2013
- HISWA Quarterly Forum, December 2013
- National Centre for Epidemiology and Population Health (NCEPH), Lunchtime Seminar, March 2014
- UWA School of Population Health Tuesday Seminar, March 2014
- WA Multi-Resistant Organism Expert Advisory Group Quarterly Meeting (WAMRO EAG), August 2014
- UWA Postgraduate Student Association (PSA) Student Talks in Research (STiR) Conference, September 2014
- Presentation to Nurses, Care Managers and Infection Prevention and Control professionals at the Brightwater Care Group, November 2014
- Telethon Kids Institute Lunchtime Seminar, December 2014

2.2 OTHER ACTIVITIES

- Attended weekly CDCD Surveillance Team meetings, 2013-14
- Off-Campus Officer for UWA PSA, 2014
- Attended the Perth Epidemiology Group Annual Scientific Meeting, Perth, September 2013
- Attended OzFoodNet Face-to-Face Meeting, Perth, March 2014
- Surveyor, WA Safety and Quality Point Prevalence Survey, Sir Charles Gardiner Hospital, May 2014
3. OVERVIEW AND PLACEMENT

“...The more I learned the more I realized how very much one has to know before one is in-the-know at all.” — Julia Child, My Life in France

I first heard of the MAE from my Epidemiology lecturer when I questioned what I was going to do after my Master of Infectious Diseases degree. However I still had to complete a small research project for that degree. Somehow I convinced everyone that I would be able to complete the research project for the MInfecDis at the same time as participating full-time in the MAE program and, whilst I don’t regret this decision, I would definitely recommend against such craziness.

Over the past two years I’ve learnt you don’t just do an MAE, you are an MAE, and what you do during your two years will not only strengthen your own career, but those of your supervisors, your peers and colleagues, and future MAEs.

3.1 PERTH, WESTERN AUSTRALIA

Western Australia (WA), covering 2,529,875 km², or 1/3 of Australia, is the largest jurisdiction in Australia. WA is bordered by the Indian Ocean to the north and west, the Great Australian Bight to the South and the Northern Territory and South Australia to the east. The capital city, Perth, boasts the largest city park in the world, Kings Park and is home to 2 million people. It is in this wonderful city that I was placed for my MAE.

I was lucky to have two placements with a field supervisor at each placement; Professor Tom Riley, head of the Bacteriology Research and Development Laboratory at PathWest Laboratory Medicine (PathWest), and Dr Paul Armstrong, head of the Communicable Disease Control Directorate (CDCD) at WA Health, along with A/Prof Martyn Kirk as my academic supervisor at ANU.

3.2 BACTERIOLOGY R&D, PATHWEST LABORATORY MEDICINE

I started working on the 25th of February 2013 in the Bacteriology Research and Development (R&D) laboratory of PathWest Laboratory Medicine (PathWest) at the QEII Medical Centre (QEIIIMC) in Perth. PathWest provides diagnostic services for a network of approximately 50 branch laboratory and collection centres and a comprehensive courier system. There are four main divisions in PathWest:

- Division of Clinical Pathology
- Division of Microbiology and Infectious Diseases
- Division of Tissue Pathology
- Division of Branch Laboratories
The Division of Microbiology and Infectious Diseases is accredited by National Association of Testing Authorities (NATA), as well as by the Australian Quarantine and Inspection Service (AQIS). The division is further split into sections:

- Molecular Diagnostics and Serology
- Clinical Bacteriology
- Mycobacteriology
- Mycology
- Enterics
- Foods and Waters
- Bacteriology R&D

I had previously been working as a Technical Assistant in the Clinical Bacteriology laboratory of PathWest for the previous 18 months so I already knew my way around. During my placement, PathWest moved into their new premises on the QEIIIMC site. The new R&D office location meant that everyone was in one room, rather than split across three separate offices, which made for lots of communal effort, not only in work activities, but at lunch and being sociable after hours.

The focus of my work whilst at the Bacteriology R&D Laboratory was my epidemiological project. Following on from my previous work, I performed a cross-sectional survey of gastrointestinal carriage of and environmental contamination with *C. difficile* in aged care facilities. For this project, I was able to perform all the field and laboratory work. This research was performed with a prominent not-for-profit care organisation, located in the northern suburbs of metropolitan Perth. In November 2014, I presented these findings at the ACIPC Conference in Adelaide, South Australia.

### 3.3 Communicable Disease Control Directorate, WA Health

The CDCD is part of the Public Health division of WA Health, which contains five program groups; Epidemiology and Surveillance, Prevention and Control, Healthcare Associated Infection Unit (HAIU), Sexual Health and Blood-Borne Virus, and Case Management.

My placement at the CDCD, I worked with the HAIU to evaluate the HISWA system in accordance with the Centers for Disease Prevention and Control (CDC) guidelines for evaluating a public health surveillance system. I also assisted the HAIU in investigating an outbreak of community-associate methicillin-resistant *Staphylococcus aureus* (CA-MRSA) associated with an abattoir.

Whilst at the CDCD I attended weekly Surveillance Team meetings where the weekly notification report was discussed amongst the Surveillance and Epidemiology team members. I worked with the OzFoodNet team to investigate an outbreak of norovirus in the Kimberley and attended the OzFoodNet face-to-face meeting in Perth. I also joined Dr Armstrong as a member of the working group investigating a pseudo-outbreak of Barmah Forest virus (BFV) for the Communicable Disease Network of Australia (CDNA).
4. SUMMARY OF PROJECTS

The following paragraphs are overviews of the projects contained within this thesis; each one of these projects involves analysis of infectious diseases which effect the West Australian population.

4.1 GASTROINTESTINAL CARRIAGE OF AND ENVIRONMENTAL CONTAMINATION WITH CLOSTRIDIUM DIFFICILE IN AGED CARE RESIDENTIAL FACILITIES

The aim of this study was to determine the prevalence of asymptomatic C. difficile gastrointestinal carriage and the prevalence of environmental contamination with C. difficile within aged care facilities and residents in WA.

4.2 EVALUATION OF THE HEALTHCARE INFECTION SURVEILLANCE WESTERN AUSTRALIA (HISWA) SYSTEM

An overall evaluation of the entire HISWA system had not been performed since the inception of the program in 2005. By evaluating HISWA, areas of improvement were identified to ensure robust surveillance of healthcare associated infections across WA healthcare facilities. This evaluation also coincides with the proposal of upgrading HISWA and introducing a standardised automated surveillance technology for the capturing of infection surveillance data.

4.3 INVESTIGATION OF A PSEUDO-Epidemic of BARMAH FOREST VIRUS (BFV) ACROSS AUSTRALIA

From October 2012 the rate of BFV notifications noticeably increased across all jurisdictions and peaked in April 2013. These notifications came from areas which did not traditionally experience arboviral disease. This was especially noted within the suburbs of Perth, WA.

In July 2013, the Communicable Disease Network of Australia (CDNA) formed the BFV Working Group (WG) to identify reasons for dramatic increases in BFV notifications across Australia. Investigations by the WG included a survey of laboratories regarding their testing procedures, several laboratory evaluations of the test kit, and an analysis of national notification data from 2001 – 2013.

This chapter is a combination of two bodies of work; 1) the analysis results from the national notification data for BFV from 1 January 2001 – 31 December 2013, and 2) a report to the CDNA on the findings from the working group investigating the pseudo-outbreak.
4.4 **Outbreak Investigations**

4.4.1 **MRSA**

This report discusses a cluster of community-acquired methicillin-resistant Staphylococcus aureus (CA-MRSA) cases associated with an abattoir. All MRSA cases are notifiable within WA.

4.4.2 **Norovirus**

This is report of a small outbreak investigation after six people attended the emergency department with diarrhoea and vomiting after eating at a hotel restaurant in Northern WA.

4.5 **Teaching Exercises**

For the teaching assignment of “Issues in Applied Epidemiology” I worked with Tim Sloan-Gardiner to present a lesson on “Critical Appraisal of Scientific Literature” during our 3rd course-block in March 2014.

For my Lesson from the Field, I presented on “Sample Size and Power Calculations”, creating an overview document on the why and how of sample size and power calculations, and three example exercises for participants to complete."
Chapter 2
Gastrointestinal Carriage of Clostridium difficile in Aged Care Residents and the Contamination of the Facility Environment
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PROLOGUE

MY ROLE

My role in this study was as key researcher. I designed the study, applied for ethical approval from the appropriate committees, co-ordinated and conducted the collections of specimens and data in the field, performed all laboratory experiments, entered and analysed the data and wrote the final report.

The method for environmental sampling used in this project was developed and evaluated as part of my Master of Infectious Disease (2013) research project "An Environmental Survey of Clostridium difficile in Seven Residential Aged Care Facilities”.

LESSONS LEARNT

In this project, I learnt a lot about time and resource management, for example, liaising with the facilities for the most suitable time for testing, ensuring that I had enough supplies for testing, and working around regular diagnostic laboratory testing requirements. I learnt that methods must be flexible, and that research projects which involve other people will not go to plan. I also learnt the value of a data dictionary, especially when you return to your data several months later.

PUBLIC HEALTH IMPACT

Asymptomatic carriage of and environmental contamination with C. difficile in aged care facilities in Australia is poorly understood, with few investigations currently published in scientific literature. This project has identified a potential reservoir for C. difficile within aged care facilities, which may undermine current infection prevention and control policies. The results of this project may influence policy makers regarding C. difficile infections in aged care facilities.

ACKNOWLEDGEMENTS

This study was performed with supervision from Prof Thomas Riley and A/Prof Martyn Kirk, with advice from Dr Niki Foster, Dr Kate Hammer, Karla Seaman, and Marilyn McCarthy. Deidre Collins, Stacey Hong, Pim Putsathit, Grace Androga and Dr Peter Moono assisted with me with field work, Alan McGovern helped with the molecular laboratory work, and Deirdre Collins and Dr Briony Elliot helped with the assignment of ribotypes.
ABSTRACT

*Clostridium difficile* is a major cause of antibiotic-associated diarrhoea, and *C. difficile* infections (CDI) occur at higher rates in the elderly. Overseas studies have found rates of asymptomatic carriage of *C. difficile* in elderly persons living in residential from 4% to 20%, but few studies have determined the carriage rate in Australian aged-care facilities (ACFs). Carriers of *C. difficile* may shed spores into the environment, potentially putting other residents at risk.

This cross-sectional study was conducted to determine the prevalence of *C. difficile* in residents of seven ACFs, and with the extent of environmental contamination of the facilities with *C. difficile*. All residents were eligible to participate by supplying a faecal sample for testing. If a resident passed a bowel movement between 6am and 12pm on the selected day of testing, it was collected. If the resident participated in the prevalence study, environmental samples were taken from the floor and door handles of their bathroom.

A total of 118 stools were collected across the six days of testing, representing 33.6% of all residents. The prevalence of asymptomatic carriage of *C. difficile* in the ACF residents tested to be 7.6% (95%CI 3.1 - 12.2) among those who supplied samples. From the 95 environmental samples collected, five residents’ rooms tested positive for *C. difficile* either on the floor, door handles or both locations (5.3%, 95%CI 0.9 - 9.6). Floors were more likely to be contaminated than doors (4:1 respectively). Residents with a positive faecal sample were significantly more likely to have a living environment that was positive for *C. difficile* (RR 36, 95%CI 8.5 – 151.8, p <0.01).

Undetected carriage, shedding and transmission of *C. difficile* are clearly occurring in Australian ACFs. This may result in outbreaks of serious CDI due to the high risk profiles of residents in these facilities. Continuing contact precautions after the resolution of diarrhoeal symptoms may be beneficial to limit spread of infection. Current routine cleaning procedures may not be adequate for *C. difficile* contamination and should be reconsidered to improve environmental control.
# ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
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<tbody>
<tr>
<td>ACF</td>
<td>Aged care facility</td>
</tr>
<tr>
<td>AIHW</td>
<td>Australian Institute for Health and Welfare</td>
</tr>
<tr>
<td>ASID</td>
<td>Australasian Society for Infectious Diseases</td>
</tr>
<tr>
<td>BA</td>
<td>Blood agar</td>
</tr>
<tr>
<td>CA</td>
<td>ChromID <em>C. difficile</em> agar</td>
</tr>
<tr>
<td>CDI</td>
<td><em>C. difficile</em> infection</td>
</tr>
<tr>
<td>CDT</td>
<td><em>C. difficile</em> toxin</td>
</tr>
<tr>
<td>CFR</td>
<td>Case fatality rate</td>
</tr>
<tr>
<td>CFU</td>
<td>Colony forming units</td>
</tr>
<tr>
<td>CHOC</td>
<td>Chocolate agar</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
</tr>
<tr>
<td>EIA</td>
<td>Enzyme immunoassay</td>
</tr>
<tr>
<td>ESBL</td>
<td>Extended spectrum β-lactamase producing organisms</td>
</tr>
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<td>FBC</td>
<td>Full blood count</td>
</tr>
<tr>
<td>GDH</td>
<td>Glutamate dehydrogenase</td>
</tr>
<tr>
<td>HREC</td>
<td>Human Research Ethics Committee</td>
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<tr>
<td>IBS</td>
<td>Irritable Bowel Syndrome</td>
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<tr>
<td>PCR</td>
<td>Polymerase chain reaction</td>
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<td>PMC</td>
<td>Pseudomembranous colitis</td>
</tr>
<tr>
<td>PSU</td>
<td>Population sampling unit</td>
</tr>
<tr>
<td>rcf</td>
<td>Relative centrifugal force</td>
</tr>
<tr>
<td>RCM + GCC</td>
<td>Robertson’s Cooked Meat + 5 mg/L gentamicin, 10 mg/L cefoxitin, 200 mg/L cycloserine</td>
</tr>
<tr>
<td>RNA</td>
<td>Ribonucleic acid</td>
</tr>
<tr>
<td>RR</td>
<td>Risk ratio</td>
</tr>
<tr>
<td>rtPCR</td>
<td>Real-time polymerase chain reaction</td>
</tr>
<tr>
<td>TA</td>
<td>Taurocholic acid</td>
</tr>
<tr>
<td>VRE</td>
<td>Vancomycin resistant <em>Enterococcus</em></td>
</tr>
<tr>
<td>WCC</td>
<td>White cell count</td>
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1. LITERATURE REVIEW

1.1 AGEING AND AGED CARE

1.1.1 AGEING IN AUSTRALIA

Data published by the Australian Bureau of Statistics in June 2014 showed that Australia is getting older; three decades ago the median age of the Australian population was 30.5 years, today it is 37.3 years and in 2044 it is projected to be 40 years. The proportion of ‘older Australians’ in the population, defined as those aged 65 years and older, has increased over the past 25 years, from 10.5% to 14.4% in 20131.

Older Australians are generally healthier and have longer life expectancies than previous generations, with men aged 65 today expected to live for a further 19.1 years and women a further 22.0 years2. The life expectancy of Australians is one of the highest of any country in the world, with Australia ranking seventh among Organisation for Economic Co-operation and Development countries3.

The Australian Institute for Health and Wellbeing (AIHW) defines an aged care facility (ACF) as “a special-purpose facility which provides accommodation and other types of support, including assistance with day-to-day living, intensive forms of care, and assistance towards independent living, to frail and aged residents”4. The proportion of older Australians who resided in some form of ACF was approximately 5% (166,717) in 2013. For those in long-term residential care, nine of 10 residents will remain in care until death1,4.

1.1.2 AGEING AND THE GASTROINTESTINAL SYSTEM

Ageing has been defined as “the regression of physiological function accompanied by the development of age”5. Ageing in a biological sense is referred to as “senescence” and is classified as the declining ability to respond to stress, increasing homeostatic imbalances and risk of disease5,6. In the gastrointestinal system, ageing results in a decline in intestinal motility, increasing transit time and thereby increasing the risk of constipation5. The reduction in intestinal motility affects the gut fermentation process adversely. The dominant bacterial species present in faeces changes significantly in elderly people when compared to younger adults (aged 25-40 years), reducing biodiversity, compromising the stability of the gut microbiota and increasing the overall number of facultative anaerobes. Despite this, there is no increase in the numbers of strict anaerobic bacteria5,7-9, such as *Clostridia* spp. The changes due to ageing in the gastrointestinal tract lead to dramatic
changes to the homeostatic equilibrium between microbiota and host, causing immunosenescence and chronic activation of the immune system or “inflamm-ageing”5,10.

Not only does the biodiversity of gut microbiota change with ageing, but also between people and their environment. The microbiota of elderly people within the same ethnogeographic region differs between those living long-term in ACFs and those living in the community10. It is thought that the differences in microbiota composition is due to the dietary habits of those living in ACFs with decreased dietary diversity leading to decreased faecal microbiota range10.

Reduced bacterial diversity has been linked with *C. difficile* infections (CDI) and asymptomatic carriage of *C. difficile*8,9. It has been hypothesized that commensal microbiota may exert a protective role by preventing potentially pathogenic *C. difficile* from overcoming colonisation resistance, proliferating in the colon and producing toxins8,9.

1.1.3 *AGED CARE AND GASTROENTERITIS*

Residents of ACFs are commonly of poorer health status than those of similar age residing within the community11. Along with the decrease in health comes an increased use of medication, including antibiotics. High rates of antibiotic use may contribute to enteric illness by decreasing harmless, competing gut flora11. Poorer health of ACF residents means it is often difficult to distinguish between faecal incontinence, faecal impaction with encopresis, irritable bowel syndrome (IBS), and laxative or drug induced diarrhoea12.

Table 1 indicates some of the potential causative pathogens for diarrhoeal outbreaks in ACFs13. In Australia during 2007, it was estimated that reports of gastroenteritis to health departments from ACFs accounted for 54% (1,010) of all gastroenteritis outbreaks (1,882) notified Australia-wide. Overseas, 12-57% of gastroenteritis outbreaks are reported from ACFs13. Transmission of enteric pathogens in ACFs is frequently by the person-to-person route, and close contact during care-giving or touching of common surfaces11.

Whilst not commonly reported, *C. difficile* is also a cause of gastroenteritis in ACFs, with recent studies suggesting colonisation with toxigenic *C. difficile* is significantly higher in residents of ACFs than in the general population14-16. More than 80% of reported cases of CDI occur in adults aged 65 and older17. Detection of the causative agent in a diarrhoeal outbreak is important as infection prevention and control management strategies are different for various pathogens12,16. A misdiagnosis may hamper the efforts of the infection prevention and control team in ceasing the outbreak, as well as lead to incorrect treatment and management of patients19,20.
Table 1. Potential causative pathogens of diarrhoeal outbreaks in aged care facilities\(^{12,13}\)

<table>
<thead>
<tr>
<th>Agent</th>
<th>Signs and Symptoms</th>
<th>Incubation Period</th>
<th>Shedding post-infection</th>
<th>Transmission</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norovirus</td>
<td>Vomiting, nausea, abdominal pain, anorexia, diarrhoea</td>
<td>24 – 48 hours</td>
<td>2 – 45 days</td>
<td>Person-person Foodborne</td>
<td>Major cause of gastroenteritis in facilities</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>Diarrhoea, vomiting, fever</td>
<td>24 – 72 hours</td>
<td>1 – 20 days</td>
<td>Person-person</td>
<td>Outbreaks most common during winter</td>
</tr>
<tr>
<td><em>Salmonella</em> <em>enterica</em></td>
<td>Diarrhoea, vomiting, abdominal pain, blood in stool, fever</td>
<td>24 – 72 hours (or longer)</td>
<td>1 – 21 days</td>
<td>Foodborne</td>
<td>Has been known to cause deaths in elderly</td>
</tr>
<tr>
<td><em>Campylobacter</em> <em>spp.</em></td>
<td>Diarrhoea with blood, vomiting, abdominal cramps, fever</td>
<td>2 – 5 days</td>
<td>1 – 69 days</td>
<td>Foodborne</td>
<td>Uncommon cause of sporadic infections</td>
</tr>
<tr>
<td><em>Clostridium</em> <em>perfringens</em></td>
<td>Watery diarrhoea, abdominal pain, nausea</td>
<td>8 – 16 hours</td>
<td>N/A</td>
<td>Foodborne</td>
<td>Routine laboratory testing will not detect as illness is toxin mediated</td>
</tr>
<tr>
<td><em>Clostridium</em> <em>difficile</em></td>
<td>Diarrhoea, colitis, abdominal pain, fever, leucocytosis</td>
<td>1 – 10 days</td>
<td>1 – 28 days</td>
<td>Person-person</td>
<td>Common cause of antibiotic-associated diarrhoea</td>
</tr>
<tr>
<td><em>Listeria</em></td>
<td>Headache, myalgia, fever, abdominal pain, chills, coma</td>
<td>&gt;30 days</td>
<td>N/A</td>
<td>Foodborne</td>
<td>Comprehensive investigation of food history and clinical records. CFR in elderly 20-30%.</td>
</tr>
</tbody>
</table>

**CFR**: Case Fatality Ratio **N/A**: Not available
1.2 Clostridium difficile

*Clostridium difficile* is a Gram positive, spore forming, rod-shaped bacillus that has a distinct “horse stable” odour when cultured in the laboratory (Figures 1a and b). *C. difficile* is a strict anaerobe, meaning it cannot grow in the presence of oxygen and must be incubated in anaerobic conditions. *C. difficile* was first described in 1935 when it was named *Bacillus difficile*, due to the difficulties in isolating it. It is estimated that $1 \times 10^4$-$1 \times 10^7$ vegetative cells of *C. difficile* are excreted per gram of faeces in active CDI patients.

![Figure 1a](image1.png) Gram stain of *C. difficile* (magnification x1500) ![Figure 1b](image2.png) *C. difficile* colonies on blood agar after 48h incubation at 37°C in anaerobic conditions (A Williams, 2013)

*C. difficile* can produce three toxins – A, B and binary toxin. *C. difficile* strains are either toxigenic or non-toxigenic; only those that are toxigenic can cause disease.

1.3 Asymptomatic carriage of *C. difficile* in ACFs

The definition of an asymptomatic carrier is someone who “harbours the pathogen and is able to transmit it but shows no clinical signs of infection”\(^\text{23}\). Asymptomatic carriage of non-toxigenic *C. difficile* is not considered a risk factor for the development of CDI, but instead may be protective\(^\text{24,25}\). Exposure to asymptomatic individuals with toxigenic *C. difficile* may be the potential source for unexplained CDI cases in close contacts\(^\text{25}\). Many studies report epidemiological and molecular links between asymptomatic carriers and CDI cases within facilities\(^\text{25-29}\). The reported rate of asymptomatic carriage for *C. difficile* varies\(^\text{10}\); carriage rates of *C. difficile* in ACF residents have been reported from as low as <1%\(^\text{30}\) to as high as 51%\(^\text{31}\) (Table 2). However, it is necessary to note that diagnostic methods and case definitions for carriage differ between studies, making meaningful comparison of rates in these studies difficult\(^\text{14}\). Table 2 lists both reports of CDI and investigations of asymptomatic carriage, demonstrating that *C. difficile* represents a significant burden for ACFs.
<table>
<thead>
<tr>
<th>1st Author, year</th>
<th>Study type</th>
<th>Setting Country</th>
<th>Samples/data collected</th>
<th>Results</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campbell 32, 2009</td>
<td>Descriptive study</td>
<td>210 HCFs + 955 NHs Ohio, USA</td>
<td>Active public reporting, Jan 1 - Dec 31, 2006</td>
<td>14,329 CDI cases: 6,376 HCF (44.5%), 7,953 NH (55.5%)</td>
<td>Mean of initial cases in NH 407 cases/month</td>
</tr>
<tr>
<td>Goldstein 33, 2009</td>
<td>Observational</td>
<td>LTCF admissions Los Angeles, California, USA</td>
<td>36 admissions; 31 samples collected</td>
<td>4 of 31 (12.9%) of patients tested positive on admission; 2 (6.5%) asymptomatic carriers, 2 (6.5%) active CDI</td>
<td>20/36 (55.5%) developed diarrhoea</td>
</tr>
<tr>
<td>Ryan 34, 2010</td>
<td>Prevalence</td>
<td>Long term care and rehabilitation wards Cork, Ireland</td>
<td>175 patients 100 stool samples</td>
<td>17 putative C. difficile; 10 toxigenic C. difficile (10%), 7 C. sordelli</td>
<td>Non-carriers were less likely to have recently used antibiotics (p 0.0046).</td>
</tr>
<tr>
<td>Archbald-Pannone 35, 2010</td>
<td>Observational</td>
<td>180-bed LTCF Charlottesville, Virginia, USA</td>
<td>46 stool specimens convenience sampling</td>
<td>2 positive (4.3%)</td>
<td>Most common ribotypes UK003, UK005 and UK106 All aged ≥70 (median 81 years)</td>
</tr>
<tr>
<td>Miyajima 36, 2011</td>
<td>Cross-sectional cohort longitudinal study</td>
<td>Community-based Manchester, UK</td>
<td>206 residents 149 stool specimens</td>
<td>6 carriers (4.6%)</td>
<td>Most common ribotype UK072 and UK027</td>
</tr>
<tr>
<td>Rea 37, 2011</td>
<td>Prevalence</td>
<td>ELSERMET cohort Cork, Ireland</td>
<td>317 specimens: 123 community members, 43 outpatients, 48 rehabilitation patients, 103 long-term hospitalised</td>
<td>28 (8.8%) CDI; Community: 1.6%, Outpatients: 9.5%, Rehabilitation: 0%, Long-term hospitalised: 13%</td>
<td>Most common ribotype UK072 and UK027</td>
</tr>
<tr>
<td>Stuart 30, 2011</td>
<td>Point-prevalence</td>
<td>3 RACFs, 164 beds Melbourne, Australia</td>
<td>164 stool samples</td>
<td>1 positive for C. difficile (0.6%)</td>
<td>Also tested for prevalence of VRE (2%) and ESBL E. coli (12%)</td>
</tr>
<tr>
<td>Arvand 15, 2012</td>
<td>Cross-sectional</td>
<td>LTCF + community volunteers Hesse, Germany</td>
<td>240 LTCF + 249 Community stool specimens</td>
<td>Asymptomatic carriage of C. difficile in 11 (4.6%) LTCF residents and in 2 (0.8%) community participants</td>
<td>Ribotypes UK014 and UK001 most common</td>
</tr>
<tr>
<td>Di Bella 38, 2013</td>
<td>Retrospective cohort</td>
<td>5 urban hospitals Rome, Italy</td>
<td>4951 routine stool samples submitted for testing</td>
<td>402 CDI episodes over 6-year period</td>
<td>77% in &gt; 60 years of age CDI increased with age 3.4% in 18-14 to 16.1% in &gt; 80</td>
</tr>
</tbody>
</table>
Table 2 cont. Articles regarding prevalence of *Clostridium difficile* in the elderly 2009 – 2014

<table>
<thead>
<tr>
<th>1st Author, year</th>
<th>Study type</th>
<th>Setting Country</th>
<th>Samples/data collected</th>
<th>Results</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eckert 39, 2013</td>
<td>Descriptive study</td>
<td>105 HCF acute wards 95 LTCF wards France</td>
<td>Active public reporting to the French Public Health Surveillance Institute over 6 months</td>
<td>1316 cases HCF (2.28 per 10,000) 295 cases LTCF (1.15 per 10,000)</td>
<td>The five major PCR-ribotypes were UK014/020/077 (18.7%), UK078/126 (12.1%), UK015 (8.5%), UK002 (8%), and UK005 (4.9%).</td>
</tr>
<tr>
<td>Guerrero 28, 2013</td>
<td>Point-prevalence</td>
<td>215-bed, 8 ward HCF Cleveland, Ohio, USA</td>
<td>160 patients 149 rectal swabs</td>
<td>18 asymptomatic carriers of toxigenic <em>C. difficile</em> (12.1%, 95%CI 7.8% – 18.3%)</td>
<td>Age range: 55–73 years’ old</td>
</tr>
<tr>
<td>Marwick 40, 2013</td>
<td>Prospective cohort with nested case-control</td>
<td>All residents ≥65 years Tayside, Scotland</td>
<td>79,039 eligible residents</td>
<td>156 CDI in 137 persons CDI incidence was 20.3/10,000 person years</td>
<td>Increased risk of CDI with increased age, comorbidity, prior HCF admission, care home residence [HR: 1.96, 95%CI 1.14–3.34]</td>
</tr>
<tr>
<td>Mylotte 41, 2013</td>
<td>Retrospective cohort</td>
<td>Community NH Buffalo, NY, USA</td>
<td>75 incident CDI cases</td>
<td>52 (69%) CDI within ≤30 days of admission, 23 (31%) CDI ≥30 days after admission</td>
<td></td>
</tr>
<tr>
<td>Rogers 42, 2013</td>
<td>Cross-sectional</td>
<td>2 LTCF wards 1 spinal injury ward Cleveland, Ohio, USA</td>
<td>60 inpatients, 50 swabs 32 LTCF residents, 18 spinal injury</td>
<td>20 positive toxigenic <em>C. difficile</em> (40%)</td>
<td>Performed comparison of perirectal and rectal swabs</td>
</tr>
<tr>
<td>Galdys 43, 2014</td>
<td>Descriptive study</td>
<td>Healthy adult residents (≥18 years) Pittsburgh, PA, USA</td>
<td>130 participants 106 stool specimens</td>
<td>7 (6.6%) positive for toxigenic <em>C difficile</em>, no non-toxigenic strains.</td>
<td>Compared molecular assays to anaerobic culture methods</td>
</tr>
</tbody>
</table>

**CDI:** *Clostridium difficile* infection **CI:** Confidence Interval **ESBL:** Extended Spectrum β-lactamase producing organisms **GDH:** Glutamate Dehydrogenase **HR:** Hazard Ratio **HCF:** Healthcare facility **LTCF:** Long Term Care Facility **NH:** Nursing Home **RACF:** Residential Aged Care **VRE:** Vancomycin resistant Enterococci
There is also an increase of CDI cases reported across the world\(^ {38} \). Asensio \textit{et al.} reported an increase in CDI from 3.9 to 12.2 cases per 10,000 hospitalised patients from 1999 through 2007 in Spain\(^ {44} \); Burckhardt \textit{et al.} reported an increase from 1.7 to 14.8 cases per 100,000 people from 2002 to 2006 in Germany\(^ {45} \), whilst Di Bella \textit{et al.} reported an increase from 0.3 in 2006 to 2.3 per 10,000 patient-days in 2011 in Italy\(^ {38} \) (Table 2). In Australia the annual rate of CDI has increased from 3.25/10,000 patient-days in 2011 to 4.03/10,000 patient-days in 2012\(^ {46} \). However, it was estimated that 30-40% of CDI cases were community-associated as \textit{C. difficile} is not solely a nosocomial issue. Data from the United States, Canada, and Europe suggest that approximately 20%–27% of all CDI cases are community associated, with an incidence of 20–30 per 100,000 persons\(^ {47} \). Reports of increasing rates of CDI cases around the world may be due to a range of causes including an ageing population, increase in elderly living within residential care facilities, changes in virulence of infecting agents, or increased screening leading to a reporting artefact.

In the ELDERMET prevalence survey investigating the association between gut microbiota, food and health of the elderly in Ireland\(^ {37} \), the rate of asymptomatic carriage of \textit{C. difficile} in those that lived in the community was 1.6%, whilst those that lived in ACF long term had carriage rates of 13%\(^ {6} \). A difference in rates of carriage between community and ACF residents was also found in the UK\(^ {40} \), Germany\(^ {15} \) and USA\(^ {32} \) (Table 2). This difference is thought to be due to the variance in microbiota of elderly people between those living in ACFs and those living in the community\(^ {10} \).

### 1.4 Transmission of \textit{C. difficile}

\textit{C. difficile} is spread from person-to-person or via contact with contaminated surfaces\(^ {31,48} \). \textit{C. difficile} produces spores; resistant structures that can tolerate unfavourable conditions such as extreme temperatures or chemical products. These characteristics mean spores can persist in the environment for months to years before germination\(^ {22} \). There is evidence that carriers of \textit{C. difficile} shed spores into the environment\(^ {31} \) and that \textit{C. difficile} is spread through the dissemination of these spores\(^ {22} \). \textit{C. difficile} can be recovered from multiple skin sites, including groin, chest, abdomen, forearms and hands of colonised patients\(^ {31,48} \). \textit{C. difficile} can also be recovered from investigators’ hands after contact with colonized individuals, which can then spread onto equipment, surrounding environment, and other residents\(^ {31,49,50} \). Whilst disinfectants may kill vegetative cells, spores can last on surfaces after disinfection\(^ {51} \); the contaminated environment then becomes a reservoir\(^ {52} \).

Riggs and colleagues performed parallel environmental and skin sampling and found that those who were asymptomatic carriers were more likely to have \textit{C. difficile} on their skin.
than those who did not ($p=0.001)^{31}$. Despite lower levels of skin and environmental contamination compared to symptomatic cases, asymptomatic carriers of \textit{C. difficile} had statistically higher percentages of recovery of \textit{C. difficile} from skin ($p=0.001$) and environmental samples ($p=0.004$) than non-carriers$^{31}$. Curry \textit{et al.} found that approximately 29\% of hospital-associated CDI cases were highly related (by molecular typing) to isolates found in patients with asymptomatic carriage of \textit{C. difficile}, suggesting that asymptomatic carriers are involved in the transmission of \textit{C. difficile}$^{27}$.

### 1.5 Infections Caused by \textit{C. difficile}

For a CDI to be diagnosed, at least one of the following must be found$^{18,53,54}$:

1. Diarrhoeal stools (Bristol Stool types 5-7) (Appendix 1) are \textit{C. difficile} toxin positive or toxigenic \textit{C. difficile} is detected in stool without reasonable evidence of another cause of diarrhoea
2. Toxic megacolon or ileostomy where a specimen is \textit{C. difficile} toxin positive
3. Pseudomembranous colitis is diagnosed during endoscopy, after colectomy or on autopsy
4. Colonic histopathology is characteristic of CDI (with or without diarrhoea or toxin detection) on a specimen obtained during endoscopy or colectomy
5. Faecal specimens collected post-mortem are \textit{C. difficile} toxin positive or tissue specimens collected post-mortem where pseudomembranous colitis is revealed or colonic histopathology is characteristic of CDI

#### 1.5.1 Mild and Moderate Infection

Mild CDI is not associated with any systematic toxicity or rise in white cell count (WCC), and results in $\sim$3 diarrhoeal stools per day (type 5–7 Bristol Stool Chart) (Appendix 1). Moderate CDI is typically associated with 3–5 diarrhoeal stools per day as well as a raised WCC (greater than $15\times10^9$ cells/L)$^{18,53,54}$.

#### 1.5.2 Severe Infection

Many studies have attempted to determine clinical indicators as predictors of severe CDI (Table 3). Overall, patients aged over 65 years who present with $\geq20,000$ WCC/μL, increased serum creatinine greater than 1.5 times baseline levels and hypoalbuminaemia are at the greatest risk of developing severe CDI. Kyne \textit{et al.} found that patients with severe underlying co-morbidities at the time of admission were at higher risk of severe CDI$^{55}$. 

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1.5.3 Fulminant Infection

Cases of fulminant CDI present with the symptoms of severe CDI as well as systemic toxicity, shock, and toxic ileus or megacolon. Usually these patients require admission to ICU as well as surgical intervention\(^{18,56}\). An urgent colectomy increases survival rates of fulminant CDI cases\(^{56,57}\) and is recommended by ASID\(^{18}\).

Table 3. Clinical indicators of severe C. difficile infections

<table>
<thead>
<tr>
<th>First Author/ Year</th>
<th>WCC</th>
<th>Serum Albumin</th>
<th>Serum Creatinine</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brandt(^{58}) 1999</td>
<td>&gt;10,400 cells/mm(^3)</td>
<td>hypoalbuminaemia</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Dubberke(^{59}) 2007</td>
<td>--</td>
<td>Low (2.5-3.5g/dL)</td>
<td>--</td>
<td>mechanical ventilation</td>
</tr>
<tr>
<td>Henrich(^{60}) 2009</td>
<td>&gt;20,000 µL</td>
<td>&lt;2.5g/dL</td>
<td>&gt;2g/dL</td>
<td></td>
</tr>
<tr>
<td>Fujitani(^{61}) 2011</td>
<td>≥20,000 cells/mm(^3)</td>
<td>hypoalbuminaemia</td>
<td>--</td>
<td>abdominal distension, fever</td>
</tr>
<tr>
<td>Lungulescu(^{62}) 2011</td>
<td>&gt;20,000 cells/dL</td>
<td>&lt;3.0mg/dL</td>
<td>&gt;1.5 times baseline</td>
<td>history of malignancy</td>
</tr>
<tr>
<td>Kelly(^{63}) 2012</td>
<td>&gt;20,000 cells/mm(^3)</td>
<td>--</td>
<td></td>
<td>increasing for mortality</td>
</tr>
<tr>
<td>Shivashankar(^{64}) 2013</td>
<td>≥15x10(^9)/L</td>
<td>--</td>
<td>≥1.5 times baseline</td>
<td>Narcotic and H2A/PPI use</td>
</tr>
</tbody>
</table>

Hypoalbuminaemia: abnormally low serum albumin. Fujitani (2011) considers <3mg/dL to be low.
Creatinine: common indicator of renal function. Normal ranges: Women: 0.5-1.0mg/dL. Men: 0.7-1.2mg/dL
H2A/PPI: Histamine-2 antagonist, protein-pump inhibitor
WCC: white cell count

1.5.4 Pseudomembranous Colitis

Pseudomembranous colitis (PMC) is a severe, acute exudative colitis more often seen in patients with severe CDI. Differential diagnosis of PMC often requires further investigation including abdominal radiography, colonoscopy, and histological samples (Figure 2)\(^{65,66}\). Abdominal radiography can aid in diagnosis of severe complications of PMC, including toxic megacolon and rupture (Figure 2a). The macroscopic appearance of PMC upon colonoscopic investigation shows plaques (Figure 2b). Biopsies of the plaques are used for histological confirmation of PMC (Figure 2c)\(^{65,66}\).
1.5.5 Death

Severe complications of CDI that may lead to death include bowel perforation, hypotension, partial or complete ileus or toxic megacolon. In separate studies, both Sailhamer\textsuperscript{56} and Dudukgian\textsuperscript{57} found that there are three predictors of mortality with CDI:

1. **Older age:** patients who are over 70 years of age
2. **Severe infection:** patients with WCC counts of less than 4,000 cells/\(\mu\)L, greater than 35,000 cells/\(\mu\)L, or had neutrophil bands greater than 10%
3. **Cardiorespiratory support:** patients who required vasopressors and/or intubation

Wilson \textit{et al.}\textsuperscript{67} found that ischaemic heart disease and hypoalbuminemia were also predictors for death, and that treatment with metronidazole in severe cases was associated with higher rates of treatment failure and death\textsuperscript{67}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure2.png}
\caption{Pseudomembranous colitis a) X-ray showing inflamed colon, b) Endoscopy showing characteristic plaques, c) Histological biopsy stained to show infiltration of neutrophils in the lamina\textsuperscript{65}}
\end{figure}

1.5.6 Recurrent Infection

Recurrent CDI is defined as a return of signs and symptoms of CDI after a period of wellness\textsuperscript{68}. Recurrence often occurs four weeks after cessation of antibiotic therapy\textsuperscript{63,69}. A meta-analysis completed by Garey \textit{et al.} found the following three factors as increasing the risk of recurrence of a CDI\textsuperscript{68}:

1. Older age
2. Continued use of antibiotics after diagnosis of infection with \textit{C. difficile}
3. Concomitant use of antacid agents

It is thought that antacids increase the pH of gastric acid, allowing the transit of vegetative cells and spores beyond the stomach into the intestines to cause infection\textsuperscript{68}. Patients who have had a previous recurrent episode of CDI are at greater risk of subsequent recurrence with each episode\textsuperscript{63,70}. Other conditions to be considered when a patient presents with
recurrent CDI include post-infectious IBS, microscopic colitis, and inflammatory bowel disease\textsuperscript{69}.

1.6 Diagnosis and Treatment of \textit{C. difficile}

Diagnosis of CDI should be considered in any patient presenting with diarrhoea up to two months after the use of antibiotics or within three days of hospital admission\textsuperscript{16,71}. Differential diagnosis of diarrhoea is important as treatment regimens may differ. The differential diagnosis of antibiotic-associated diarrhoea includes infection with other pathogens, the use of laxatives, tube feeding, ischaemic colitis and inflammatory bowel disease\textsuperscript{13,18,72}. Testing for \textit{C. difficile} is recommended only for unformed (liquid) stools (Bristol scale 5-7) (Appendix 1), as a positive result from a formed stool may only signify carriage\textsuperscript{18}.

Diagnostic tests for \textit{C. difficile} in specimens fall into five groups\textsuperscript{18}:

- faecal culture
- enzyme-immunoassay (EIA) for detection of \textit{C. difficile} glutamate dehydrogenase (GDH)
- EIA for detection of toxins A and/or B
- cell culture cytotoxicity assays
- polymerase chain reaction (PCR) based assays

A common method used for detection of \textit{C. difficile} in stool is a two-step algorithm employing a rapid sensitive screening test, such as GDH, followed by a more specific test, such as PCR or EIA for toxin. The detection of GDH by EIA has a higher sensitivity than toxin EIA, as the metabolic enzyme is produced by both toxigenic and non-toxigenic strains. GDH, encoded by the \textit{gluD} gene, is highly conserved in all ribotypes of \textit{C. difficile}\textsuperscript{73,74}.

A survey of laboratories across Australia and New Zealand performed by ASID in late 2009 – early 2010 identified the main test method used to detect \textit{C. difficile} in stool was toxin detection by EIA or immunochromatography\textsuperscript{75}. However, surveillance of CDI based solely on the use of an EIA assay is most likely to significantly underestimate numbers as the sensitivity of EIA is reported between 48-79\% when compared to toxigenic culture\textsuperscript{75}.

When CDI is diagnosed, where possible, any treatment with antibiotics, anti-peristaltic or opiate treatments should be ceased\textsuperscript{53}. Treatment options for CDI include support therapy (hydration and electrolyte replacement)\textsuperscript{18}, antibiotics active against \textit{C. difficile} (e.g. metronidazole or vancomycin)\textsuperscript{76,77}, and faecal microbiota transplantation\textsuperscript{53,78}. 
1.7 Infection Prevention and Control

1.7.1 Hand Hygiene

The WA Department of Health requires that ACFs comply with the National Hand Hygiene Initiative which includes the “5 Moments for Hand Hygiene” framework advised by the World Health Organisation (WHO)\textsuperscript{79,80}. Alcohol-based hand rubs do not prevent the spread of \textit{C. difficile} spores, as washing hands with water and soap is significantly more effective in reducing the number of \textit{C. difficile} spores on hands\textsuperscript{72,81}. However, differences in hand-hygiene procedures specific for spore-forming organisms may cause confusion, possibly decreasing compliance with hand hygiene policies\textsuperscript{10,81}.

1.7.2 Cleaning

The use of disinfectants for cleaning environments where \textit{C. difficile} is present requires the active agents that not only kill vegetative cells but also destroy spores. The effectiveness of biocidal cleaning agents can be affected by several different factors including concentration, contact time, pH, temperature, organic matter, number and condition of the bacteria (e.g. vegetative cells, biofilms, spores)\textsuperscript{82}.

The UK Health Protection Agency guidelines recommend chlorine based disinfectants at least 1000ppm when cleaning areas potentially contaminated with \textit{C. difficile}\textsuperscript{51}. The most effective agents against \textit{C. difficile} spores are oxidising agents and peroxygens, as these agents damage DNA, proteins and lipids, and interfere with spore coats rendering them unviable\textsuperscript{51}. Fawley and colleagues\textsuperscript{82} found that only chlorine containing agents (such as bleach) were active against spores, recommending dischloroisocyanurate as their choice of cleaning agent. Whilst Fawley and colleagues\textsuperscript{82} found that that neither hydrogen peroxide nor non-ionic surfactants with phosphate showed any observable effect on spores, Best and colleagues\textsuperscript{83} found that hydrogen peroxide decontamination after deep cleaning with a chlorine agent was highly effective for removing environmental \textit{C. difficile} contamination. However, long-term follow-up found that colonised patients rapidly re-contaminated the surrounding environments\textsuperscript{83}. The use of chlorine-based disinfectants has many occupational health and safety issues including safety concerns for housekeeping staff\textsuperscript{11}.

1.7.3 Behaviour Modification

Isolation and/or cohorting of \textit{C. difficile} infected residents until 48 hours after the cessation of symptoms is recommended by the WA Department of Health and has been proven effective in the control of gastroenteritis caused by a variety of pathogens\textsuperscript{84}. The allocation of separate equipment and facility staff should also be considered to reduce the
spread of infection as the dispersal of spores can be airborne\textsuperscript{22,84,85}. Whilst interaction between infected and non-infected patients should be reduced, the psychological effects of isolation should be considered\textsuperscript{86}.

For any gastroenteritis infection, visitors or staff members who has had symptoms of vomiting and/or diarrhoea should be excluded from the facility until at least 48 hours after their last episode\textsuperscript{84,87}. Facility staff, nurses and doctors should apply the SIGHT protocol when managing suspected potentially infectious diarrhoea (Table 4)\textsuperscript{53}. Patients should be monitored daily for frequency and severity of diarrhoea using the Bristol Stool Chart (Appendix 1).

**Table 4. SIGHT protocol for managing potentially infectious diarrhoea\textsuperscript{53}**

<table>
<thead>
<tr>
<th>S</th>
<th>Suspect that a case may be infective where there is no clear alternative cause for diarrhoea</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Isolate the patient and consult with the infection control team (ICT) while determining the cause of the diarrhoea</td>
</tr>
<tr>
<td>G</td>
<td>Gloves and aprons must be used for all contacts with the patient and their environment</td>
</tr>
<tr>
<td>H</td>
<td>Hand washing with soap and water should be carried out before and after each contact with the patient and the patient's environment</td>
</tr>
<tr>
<td>T</td>
<td>Test the stool for toxin, by sending a specimen immediately</td>
</tr>
</tbody>
</table>

\textit{1.7.4 Antibiotic Guidelines}

Whilst increased cleaning and modifying human behaviour may have some effect on the spread of \textit{C. difficile}, the antibiotic prescribing guidelines in an establishment also need to be addressed in order to reduce the risk of antibiotic associated diarrhoea. McNulty and colleagues\textsuperscript{88} reported the alteration of antibiotic therapy guidelines at an ACF after the implementation of strict infection control measures and increased ward cleaning failed to curb an outbreak of CDI, which reduced antibiotic costs without an increase in patient mortality or length of stay\textsuperscript{88}. In a prospective controlled interrupted time-series study over 21-months, three acute medical wards for elderly people in a teaching hospital were involved in a study looking at the effects of reinforcing a narrow-spectrum antibiotic policy on antibiotic prescription and the rates of CDI, and saw a reduction in the incident rate ratios to 0.35 (0.17 - 0.73, \textit{p} = 0.009)\textsuperscript{89}. 
2. INTRODUCTION

Both asymptomatic carriage of and environmental contamination with \textit{C. difficile} in ACFs in Australia is poorly understood, with few investigations currently published in scientific literature. The goal of this study was to answer two main questions; 1) is there is undetected asymptomatic carriage of \textit{C. difficile} within the population of residents of the ACFs in WA, and 2) do asymptomatic carriers of \textit{C. difficile} contaminate their environments more than those that do not carry \textit{C. difficile}. By answering these questions, we aimed to determine the prevalence of asymptomatic \textit{C. difficile} gastrointestinal carriage in ACF residents and the prevalence of environmental contamination with \textit{C. difficile} within ACFs.

3. METHODS

3.1 FACILITIES AND POPULATION

3.1.1 FACILITIES

This project was performed in co-operation with one of Western Australia’s largest not-for-profit providers of residential care for elderly and disabled people. Of the 13 ACFs within this organisation, six participated in this project, all located in the northern metropolitan region of Perth.

Within each facility, each resident had their own room with an adjoining private bathroom, containing a shower, toilet and wash basin. The organisation allows personal belongings and furnishings within each room. There are communal areas within the facilities, and all meals are prepared onsite.

3.1.2 POPULATION

Residents of the ACFs have different care needs, ranging from low care or “ageing in place”, to high care, with varying requirements including dementia care. The organisation also provides transitional care between the hospital and home. Each facility had a diverse population of care needs, except for the dementia care facility, which was specifically designed for the needs of the residents. The level of care required by each resident was not recorded in this study.

3.2 ETHICS

Ethical approval was obtained from the Human Research Ethics Committees (HREC) at the University of Western Australia (UWA) and the Australian National University (ANU).
Written informed consent of the residents was not required for this study as it was considered ethically defensible to not seek consent, as there would be no risk, benefit or detriment to collect faeces from the residents. All care was taken to inform the residents and/or their legal guardians of the study, with letters and information brochures being distributed to residents and/or legal guardians (Appendix 2 and 3), allowing the opportunity to opt-out of participating in the project. Letters and information for staff were distributed by the registered nurse allocated to the project at each site. All residents were eligible to participate, unless deemed unfit to participate by site management and/or care staff.

3.3 COLLECTION OF SAMPLES AND DATA

3.3.1 SAMPLE SIZE CALCULATION

The mean of previous studies which have estimated the prevalence of *C. difficile* carriage in residents of ACFs is approximately 15-20%. The total number of residents across the six ACFs at the time of this study was 351. In order to detect a 20% prevalence of asymptomatic gastrointestinal carriage of *C. difficile* with 95% confidence, 145 residents were required to participate, and at 99%, 192 residents were required.

In a pilot study, the background contamination rate of the environment with *C. difficile* at the ACFs involved in this study was approximately 4% (A Williams, MInfecDis project, 2013). Riggs *et al.* found that 40% of patients with asymptomatic carriage of *C. difficile* contaminated their environments\(^\text{31}\). Using these figures, it was estimated that 51 samples would need to be collected to determine if carriers of *C. difficile* contaminated their environments more than non-carriers, at a confidence level of 95%. The type I error probability associated with testing this hypothesis was 0.05.

3.3.2 FECAL SPECIMENS

Samples from one ACF were collected on one day, i.e. there were six days of sampling, one day for each ACF. Faecal samples were collected from any resident who passed a bowel movement between the hours of 6am and 12pm on the day of testing. Samples were not collected from residents who had opted-out or were deemed unfit to participate.

On the day of testing, care workers at each ACF placed liners within the toilets which captured the faecal sample in the toilet. Care workers went to each room throughout the morning to collect any bowel movements. Where residents used incontinence pads, care workers collected the faecal sample from the pad. Care workers transferred samples into specimen pots and labelled the pots with a unique study identifier. The unique study identifier was cross-checked with a list of residents, ensuring that only one specimen per...
resident was collected, and that no samples were collected from any resident who had opted-out. The labelled sample pots were then put into a cooler box and taken to the laboratory for processing.

### 3.3.3 Medical Information

A registered nurse assigned from each facility photocopied the required medical information from the residents’ medical and prescription charts, being careful not to include any information that could identify the resident. This information was then coded with the matching study identifier on the faecal sample. Nurses also filled in a brief medical questionnaire for each resident (Appendix 4) which was also labelled with the unique study identifier. The questionnaire sought information about patient demographics, functional status, devices or aids, episodes of diarrhoea within the previous six weeks, chronic infections, and any hospitalisations and procedures within the previous three months. Drugs of interest for this study were any drugs administered in the last six weeks which targeted the gastrointestinal system, or any class of antibiotics.

### 3.3.4 Environmental Samples

Rooms of residents who provided faecal samples were tested across 5 ACFs until 95 rooms were sampled (the sixth ACF did not participate in environmental sampling). Within each of the residents’ rooms, two sites were tested - the bathroom floor next to the toilet and the door handles into the bedroom and bathroom. Sampling occurred on the day of faecal collection, between 12 and 1pm, whilst the residents were at lunch.

To sample the floor next to the toilet, a 5 x 2cm pre-moistened sponge was wiped across a surface area of 10x10cm. The entire surface of both door handles into the bedroom and bathroom were wiped with the sponge. Each sponge was then placed into a labelled bag, placed in a cooler box and transported to the laboratory. Throughout sample collection, sterile disposable gloves were worn by the individuals performing the sampling and changed between each room.

### 3.4 Detection and Isolation of C. difficile from Samples

All samples were stored at 4°C until processed. All samples were processed in the laboratory within 24h of the sample being collected.

#### 3.4.1 Molecular Detection of C. difficile in Faecal Samples

The BDMAX™ rtPCR platform was used to detect the C. difficile tcdB gene from faecal specimens, as per the routine method employed by the Enteric Laboratory of PathWest Laboratory Medicine.
3.4.2 Isolation of C. difficile by Culture from Faecal Samples

3.4.2.1 Direct Culture
Faecal samples were inoculated onto bioMerieux ChromID C. difficile chromogenic agar plates (CA) and incubated anaerobically for 48h.

3.4.2.2 Enrichment Culture
A pea-sized amount from the original faecal sample was placed into Robertson’s Cooked Meat + 5mg/L Gentamicin, 10mg/L Cefoxitin, and 200mg/L Cycloserine (RCM + GCC) with Taurocholic Acid (TA) and incubated aerobically for 48h at 37°C. After 48h, 1mL of RCM was mixed with 1mL of absolute ethanol and left for 1h to all vegetative cells, also known as “shocking”. Using a disposable 10mL loop, this fluid was plated for single colonies on CA plates and incubated anaerobically for 48h at 37°C, checking for growth at 24h and 48h. The enrichment stage and increases the yield of recovery of C. difficile from faeces.

3.4.3 Isolation of C. difficile by Culture from Environmental Samples

3.4.3.1 Direct Culture
The sponge was placed into the provided plastic bag along with 10mL of 0.1% peptone salt solution and stomached (pummelled) for 30 seconds in a Stomacher (Colworth Stomacher 400). The fluid was squeezed from the sponge, transferred into a 10 mL tube and centrifuged for 20 minutes at 3000rcf. All but 2mL of the liquid was discarded. A 100µL aliquot was taken from the deposit and spread-plated onto CA plates, which were incubated anaerobically for 48h.

3.4.3.1 Enrichment Culture
In addition to direct culture, 500µL of deposit was added to RCM + GCC broths, which were sealed and incubated at 35°C for 7 days. After 7d, broths were “shocked” as above in section 3.4.2.2.

3.5 Identification of C. difficile
Typical growth of C. difficile appears on CA as black colonies, with rough edges and a “ground glass” texture. Any putative C. difficile colonies on CA were sub-cultured onto pre-reduced blood agar (BA) plates and incubated for 24h. Isolates were identified as C. difficile if after 24h incubation on BA they appeared off-white, flat with rough edges, had an odour described in the literature as “horse dung”, had chartreuse colony fluorescence on BA under UV light and had a positive reaction to proline-amino peptidase due to the ability to produce L-amino peptidase.
3.6 Molecular Characterisation of C. difficile Isolates

3.6.1 DNA Extraction

A full 1 µL loop of colonies from a 24h BA culture was emulsified into a 100µL pre-prepared 5% Chelex solution before being heated at 100°C for 12min and centrifuged at 10,000g for 12min at 4°C. The supernatant (approx. 50µL) was pipetted into a fresh 1.5mL biofuge tube and stored at -20°C until further use. DNA amplification was performed on the Gene Amp® 2720 Thermo Cycler (Applied Biosystems, Foster City, California) with the cycle parameters outlined in Table 5 and the primers listed in Table 6.

Table 5. DNA amplification cycle parameters used in this study

<table>
<thead>
<tr>
<th>Ribotyping</th>
<th>Toxin Typing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temp</strong></td>
<td><strong>Time</strong></td>
</tr>
<tr>
<td>Initial Cycle</td>
<td>95°C</td>
</tr>
<tr>
<td>Denaturation</td>
<td>94°C</td>
</tr>
<tr>
<td>Annealing</td>
<td>55°C</td>
</tr>
<tr>
<td>Extension</td>
<td>72°C</td>
</tr>
<tr>
<td>Final Extension</td>
<td>72°C</td>
</tr>
<tr>
<td>Hold</td>
<td>4°C</td>
</tr>
</tbody>
</table>

3.6.2 PCR Toxin Profiling

All isolates were tested by PCR for the presence of toxin A (tcdA and tcdArep), toxin B (tcdB) and binary toxin (cdtA and cdtB) genes by methods described in Kato et al. and Stubbs et al. using the DNA templates as prepared in section 2.4.3.1 and primers in Table 2.6. Banding patterns were visualised by a QIAxcel automated capillary electrophoresis system (QIAGEN) using a QIAxcel Screening DNA Gel Cartridge and method AL320.

3.6.3 Ribotyping

Isolates of C. difficile were ribotyped as per the methods of Stubbs et al., however, the PCR products were concentrated using the QIAGEN MinElute PCR purification kit and resolved on the QIAxcel using a High Resolution DNA Gel Cartridge and method OL500. The DNA templates used were as per section 2.4.3.1.

The PCR ribotyping banding patterns were imaged using QIAxcel ScreenGel software (v1.0.2.0, Ambion Inc., Austin, Texas) and analysed using BioNumerics software package v7.1 (Applied Maths, Saint-Martens-Latem, Belgium). The interpretation of band patterns was performed by dendrogram and cluster analysis using the Ranked Pearson co-efficient. The ribotyping patterns were matched against the Riley Laboratory library of reference strains, which included strains from the European Centre for Disease Prevention and
<table>
<thead>
<tr>
<th>Gene/target</th>
<th>Primer</th>
<th>Sequence (5’ – 3’)</th>
<th>Positions</th>
<th>Product Size (bp)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>tcdA</td>
<td>NK2</td>
<td>CCC AAT AGA TTC AAT ATT AAG CTT</td>
<td>2479-2505</td>
<td>252</td>
<td>Kato (1991)</td>
</tr>
<tr>
<td></td>
<td>NK3</td>
<td>GGA AGA AAA GAA CTT CTT GCT CAC TCA GGT</td>
<td>2254-2283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tcdA rep</td>
<td>NK9</td>
<td>CCA GCT GCA GCC ATA</td>
<td>8043-8060</td>
<td>1,266</td>
<td>Kato (1991)</td>
</tr>
<tr>
<td></td>
<td>NK11</td>
<td>TGA TGC TAA TGA ATC TAA AAT GGT AAC</td>
<td>6795-6824</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tcdB</td>
<td>NK104</td>
<td>GTG TAG CAA TGA AAG TCC AAG TTT ACG C</td>
<td>2945-2972</td>
<td>203</td>
<td>Kato (1998)</td>
</tr>
<tr>
<td></td>
<td>NK105</td>
<td>CAC TTA GCT CTT TGA TTG CTG CAC CT</td>
<td>3123-3148</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cdtArev</td>
<td>AGG ATT TAC TGG ACC ATT TG</td>
<td>882-860</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cdtB</td>
<td>cdtBpos</td>
<td>CTT AAT GCA AGT AAA TAC TGA G</td>
<td>368-389</td>
<td>510</td>
<td>Stubbs (1999)</td>
</tr>
<tr>
<td></td>
<td>cdtBrev</td>
<td>AAC GGA TCT CTT GCT TCA GTC</td>
<td>878-858</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16S rRNA</td>
<td></td>
<td>CTG GGG TGA AGT CGT AAC AAG G</td>
<td>1445-1466</td>
<td>various</td>
<td>Stubbs (1999)</td>
</tr>
<tr>
<td>23S rRNA</td>
<td></td>
<td>GCG CCC TTT GTA GCT TGA CC</td>
<td>20-1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Control (ECDC), and a collection of the most prevalent PCR ribotypes currently circulating in Australia (B. Elliott, unpublished data).

3.7 STATISTICAL ANALYSIS

Data were entered, stored, transformed and analysed in EpiInfo 7 (CDC, Atlanta). Risk ratios (RR) and p-values were calculated using Fisher’s exact test statistic. Where proportions were compared, z-tests and/or Mann-Whitney-Wilcoxon tests were used. Prevalence was calculated using a complex sample frequency was taken into account. The 95% confidence intervals (CI) around prevalence figures were calculated by accounting for possible clustering of cases within ACFs.

4. RESULTS

A total of 118 residents from six ACFs provided faecal samples. There were significantly more women than men in this study – 73 versus 45 respectively (p= 0.01). The median age of residents was 83 years (range 49 – 98 years), and men (80.0 years) were significantly younger than women (85.0 years) (p= 0.003).

4.1 Faecal Results

Nine residents were found to be asymptomatic carriers of C. difficile. The overall prevalence of C. difficile carriage in ACF residents was 7.6% (95%CI 3.1 – 12.2). The median age of C. difficile carriers was 80 years (range 62 – 95 years), and was not statistically different to non-carriers (p= 0.3). Four of the C. difficile carriers were male and five were female.

The majority of faecal samples (n= 46, 39.0%) were “soft”, or type 4 on the Bristol Stool scale (Appendix 1). Of the nine samples that were positive for C. difficile, four were “soft”, three were “loose”, one was “watery” and one was “firm” (Table 7).

Table 7. Macroscopic appearance of faecal samples collected in this study with corresponding Bristol Stool scale scores

<table>
<thead>
<tr>
<th>Macroscopic appearance</th>
<th>C. difficile positive [%]</th>
<th>C. difficile negative [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard (Type 1)</td>
<td>0 [0.0%]</td>
<td>19 [17.4%]</td>
</tr>
<tr>
<td>Firm (Type 2-3)</td>
<td>1 [11.1%]</td>
<td>21 [19.3%]</td>
</tr>
<tr>
<td>Soft (Type 4)</td>
<td>4 [44.4%]</td>
<td>42 [38.5%]</td>
</tr>
<tr>
<td>Loose (Type 5-6)</td>
<td>3 [33.3%]</td>
<td>22 [20.2%]</td>
</tr>
<tr>
<td>Watery (Type 7)</td>
<td>1 [11.1%]</td>
<td>5 [4.6%]</td>
</tr>
</tbody>
</table>
4.2 CLINICAL QUESTIONNAIRE

Questionnaires for 117 of the 118 residents were fully filled in by the registered nurses; one questionnaire was incomplete but the samples were still tested. Fifty-eight residents were chair-fast (49.2%), whilst 55 residents were ambulatory (46.6%). Three residents were bed-fast and one resident’s mobility status was not reported.

Similar proportions of mobility status were found for those with *C. difficile* carriage; three were ambulatory (33.3%), five were chair-fast (55.6%) and one resident’s mobility status was not reported (11.1%). Seven residents reportedly had a diarrhoeal episode within the previous six weeks; however, no specimens were collected for any resident. Eight residents had been admitted to hospital in the previous three months, ranging from one day to nine days, however, none were carriers of *C. difficile*.

4.3 MEDICAL INFORMATION

Medical information for all 118 residents who provided faecal samples was provided for analysis. No drugs were associated with carriage of *C. difficile* (Table 8). Eight of the nine residents that were positive for *C. difficile* had taken stool softeners (RR 6.5, 95%CI 0.8 - 50.5, *p* = 0.04). Seven residents were taking antibiotics at the time of the study, however, none were positive for *C. difficile* carriage. Three residents were reported to have been admitted to hospital during the previous three months to this study.

4.4 ENVIRONMENTAL CONTAMINATION

Of those 118 residents who provided samples, 95 residents’ rooms were tested for environmental *C. difficile* across 5 facilities (Table 9). Due to time and resource constraints, it was decided that the sixth facility would not be tested for environmental contamination.

Five residents’ rooms tested positive for *C. difficile* either on the floor, door handles or at both locations (5.3%, 95%CI 0.9 – 9.6). Floors were more contaminated than door handles (4:1 respectively); however due to the small number of positive results these were combined for analysis. Residents with a positive faecal sample were significantly more likely to have a positive environmental sample for *C. difficile* (RR 36, 95%CI 8.5 – 151.8; *p* <0.01).
Table 8. Association between specified medications and *C. difficile* positivity amongst residents who provided faecal samples

<table>
<thead>
<tr>
<th>Drug</th>
<th>Number [%] prescribed</th>
<th>RR</th>
<th>95%CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regularly</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-senna</td>
<td>53 [44.9%]</td>
<td>2.5</td>
<td>0.6 – 9.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Esomeprazole</td>
<td>16 [13.6%]</td>
<td>1.8</td>
<td>0.4 – 8.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Lactulose</td>
<td>25 [21.2%]</td>
<td>1.9</td>
<td>0.5 – 6.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Movicol</td>
<td>19 [16.1%]</td>
<td>0.7</td>
<td>0.08 – 4.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Ozmeprazole</td>
<td>7 [5.9%]</td>
<td>1.9</td>
<td>0.3 – 13.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Pantoprazole</td>
<td>16 [13.6%]</td>
<td>1.8</td>
<td>0.4 – 8.0</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>When required</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bisacodyl</td>
<td>27 [22.9%]</td>
<td>0.4</td>
<td>0.05 – 3.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Co-senna</td>
<td>14 [11.9%]</td>
<td>2.1</td>
<td>0.5 – 9.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Microlax</td>
<td>10 [8.5%]</td>
<td>1.4</td>
<td>0.2 – 9.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Movicol</td>
<td>18 [15.3%]</td>
<td>0.7</td>
<td>0.09 – 5.5</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Combined</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANY antibiotic</td>
<td>7 [5.9%]</td>
<td>0.0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>ANY -prazole</td>
<td>42 [35.6%]</td>
<td>2.3</td>
<td>0.6 – 8.0</td>
<td>0.3</td>
</tr>
<tr>
<td>ANY co-senna</td>
<td>65 [55.1%]</td>
<td>6.5</td>
<td>0.8 – 50.5</td>
<td>0.04</td>
</tr>
<tr>
<td>ANY movicol</td>
<td>36 [30.5%]</td>
<td>0.8</td>
<td>0.2 – 3.5</td>
<td>1.0</td>
</tr>
<tr>
<td>ANY laxative</td>
<td>90 [76.3%]</td>
<td>2.5</td>
<td>0.4 – 19.1</td>
<td>0.7</td>
</tr>
<tr>
<td>ANY drug</td>
<td>102 [86.4%]</td>
<td>--</td>
<td>--</td>
<td>0.6</td>
</tr>
</tbody>
</table>

"ANY –prazole" was defined as any drug from the prazole group which is used to treat gastroesophageal reflux disease. "ANY laxative" was defined as any laxative drug and administered either regularly or when required. This included lactulose, Microlax, Movicol and bisacodyl.

Table 9. Number of environmental samples collected and results

<table>
<thead>
<tr>
<th>Facility</th>
<th>Number samples collected</th>
<th>Number positive for <em>C. difficile</em></th>
<th>% positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>D</td>
<td>34</td>
<td>2</td>
<td>5.88</td>
</tr>
<tr>
<td>E</td>
<td>17</td>
<td>1</td>
<td>5.88</td>
</tr>
<tr>
<td>F</td>
<td>21</td>
<td>2</td>
<td>9.52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>95</td>
<td>5</td>
<td>5.26</td>
</tr>
</tbody>
</table>
4.5 **PCR Results and Ribotypes**

Six of the nine faecal samples positive for *C. difficile* were detected through the BD MAX™ rtPCR assay. All six samples that were BD MAX™ positive were also culture positive. Two of the three BD MAX™ negatives that were culture positives were non-toxigenic by PCF for toxin genes (Table 10). The third was a RT056 [A+/B+/CDT-] strain and was a false negative on the BD MAX™. None of the indeterminate or unresolved BD MAX™ results from were culture positive. All the environmental samples that had corresponding faecal samples were of the same ribotype.

**Table 10. Results of PCR toxin and ribotype from positive faecal and environmental samples**

<table>
<thead>
<tr>
<th>study ID</th>
<th>Specimen Type</th>
<th>Ribotype</th>
<th>tcdA</th>
<th>tcdArep</th>
<th>tcdB</th>
<th>cdtA</th>
<th>cdtB</th>
<th>BDMAX™</th>
</tr>
</thead>
<tbody>
<tr>
<td>E006</td>
<td>Faecal</td>
<td>QX327</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>QX327</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>E014</td>
<td>Faecal</td>
<td>UK002</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Door</td>
<td>QX327</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>A002</td>
<td>Faecal</td>
<td>UK014</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>F003</td>
<td>Door</td>
<td>UK005</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>F021</td>
<td>Faecal</td>
<td>UK056</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>UK056</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>D038</td>
<td>Faecal</td>
<td>UK010</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>UK010</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>D044</td>
<td>Faecal</td>
<td>UK251</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>UK251</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>C013</td>
<td>Faecal</td>
<td>--</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>C016</td>
<td>Faecal</td>
<td>UK051</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>C020</td>
<td>Faecal</td>
<td>--</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

(+) positive for target; (-) negative for target; * not tested
5. DISCUSSION

The hypotheses of this study were that there is undetected carriage of *C. difficile* within the population of residents of the ACFs, and that asymptomatic carriers of *C. difficile* contaminate their environments more than those that do not carry *C. difficile*.

5.1 DETECTION OF *C. DIFFICILE* IN FAECAL SAMPLES

Nine residents were found to be asymptomatic carriers of *C. difficile*. The overall prevalence of *C. difficile* carriage in the tested ACF residents was 7.6% (95%CI 3.1 – 12.2). Our study found an overall prevalence of *C. difficile* carriage within the range of previously reported rates.

5.1.1 COMPARISON OF DETECTION METHOD TO OTHER AUSTRALIAN STUDY

In a survey of ACF residents in Victoria, Stuart *et al.* found only one of 164 residents colonised with *C. difficile* (0.6%)\(^{30}\). The Stuart *et al.* study used a two-step testing algorithm – screening for GDH, then a PCR assay on the positive samples to detect genes for toxin B, binary toxin and the *tdcC* gene deletion associated with the PCR ribotype UK027. This testing algorithm has a sensitivity of 86.1%, specificity of 97.8%, positive predictive value of 88.6%, and negative predictive value of 97.2%\(^{100}\).

In this study, all faecal samples were run through the BD MAX™ Cdiff rtPCR assay and subsequently cultured on CA and enrichment culture regardless of the PCR results. In an evaluation by Le Guern *et al.* (2012), the BD MAX™ Cdiff rtPCR assay had a sensitivity of 97.7% and specificity of 99.7%\(^{90}\). Whilst it is true that the molecular assay is more sensitive than the two-step algorithm, it is important to note that PCR assays do not differentiate between asymptomatic carriage and active CDI\(^{101}\). From the Stuart *et al.* paper, it is unclear if the investigators reported non-toxigenic strains or asymptomatic carriage, as their explanation for such a low rate of *C. difficile* is a lack of clinical evidence for CDIs in the ACF, which suggests that asymptomatic carriage was not considered\(^{30}\).

5.1.2 PCR RESULTS

The false negative result (F021) on the BD MAX™ rtPCR assay could be due to two reasons; 1) there were not enough organisms in the faecal sample for detection or 2) PCR inhibitors within the faecal sample may have affected the assay.

5.1.2.1 Limit of Detection

BD estimates that the limit of detection for the BD MAX™ rtPCR Cdiff assay is approximately \(1.2 \times 10^4 - 2.6 \times 10^4\) CFU/g of faeces\(^{102}\). Whilst during an active CDI episode the faecal load of *C. difficile* is estimated between \(1 \times 10^4 - 1 \times 10^7\) CFU/g of faeces\(^{22}\), the
estimate of faecal load in asymptomatic carriage is approximately $4 \times 10^3$ CFU/g of faeces. Therefore, asymptomatic carriage of *C. difficile* may be under the limit of detection by BD MAX™.

5.1.2.2 *Effect of Compounds on PCR Assay*

Certain compounds can impact the reliability of a PCR assay; in the evaluation of the BD MAX™ rtPCR assay, melasalamine rectal suspension enemas and calcium carbonate antacids were found to be inhibitors of the PCR reaction. Over 75% of the participants in this study were taking some form of laxative or stool softening agent; the resident whose sample was a false negative for *C. difficile* on BD MAX™ was taking Movicol, calcium carbonate based antacid. It is possible that using the BD MAX™ rtPCR assay to screen for *C. difficile* in this population may give inaccurate results when patients are taking calcium carbonate.

5.1.2.3 *Faecal Consistency*

Whilst the majority of samples (5 of 6) in this study which tested positive for *C. difficile* were soft, loose or watery, one sample was firm (Table 7). In order to use the PCR assay for screening of asymptomatic carriage, further evaluation is required, as the BD MAX™ rtPCR assay has only been evaluated for soft and liquid stools and that the performance characteristics for other clinical specimen types has not be established. It appears that consistency has no effect on *C. difficile* carriage or environmental contamination.

5.1.3 *Ribotypes*

Eighty percent of strains identified in this study were toxigenic, that is, has the genetic material required to produce toxins. The ribotypes identified corresponded with common strains isolated across WA; UK014 is the most commonly isolated ribotype in hospital samples within WA (HISWA Database 2011-2012, unpublished data). Both UK056 and UK251 are strains often isolated in WA patients, however, not as frequently as UK014/020 (HISWA Database 2011-2012, unpublished data). The non-toxigenic strains identified are also commonly identified in WA (B Elliot, personal comm., 6 Nov 2014).

Whilst asymptomatic carriage of non-toxigenic *C. difficile* is thought to be protective against CDI, it is possible that contact with asymptomatic carriers of toxigenic *C. difficile* may lead to exposure and subsequent illness. Curry *et al.* found that approximately one quarter of isolates from hospital-associated CDI cases were highly related (by molecular typing) to isolates found in asymptomatic patients, suggesting that screening and isolating patients could reduce onward transmission and a reduction in CDI. Non-toxigenic *C. difficile* will not be detected by any test that specifically targets the toxin or toxin genes, either by PCR, EIA or toxigenic culture.
It is possible that one person could carry both toxigenic and non-toxigenic *C. difficile* strains. Eyre *et al.* reported that 7% of CDI are mixed infections\(^{103}\). Sample D038 was positive for the *tcdB* target when tested by the initial BD MAX™ rtPCR assay; however, when further molecular testing was performed on the cultures of *C. difficile*, the strain appeared to be non-toxigenic.

### 5.2 Medication and Clinical Questionnaire

This study did not find associations between asymptomatic carriage and the use of PPIs, H2A blockers, antacids or anti-motility agents, which have previously been associated with CDI risk\(^{59,64,68,104,105}\). The association between acid suppression and CDI is thought to be as a result of the vegetative form surviving in decreased acid environments\(^{64}\). McFarland *et al.* previously found carriage to be associated with stool softeners (RR 2.0, 95%CI 1.4 – 3.1)\(^{106}\). However, whilst stool softeners were far more commonly prescribed to those identified with *C. difficile* than those not, the difference was not statistically significant, most likely due to the small numbers in this study.

It is interesting to note that none of those residents taking antibiotics or that had been admitted to hospital during the previous three months were identified as carriers of *C. difficile* as antibiotics and hospitalisations have been identified as risk factors for CDI\(^{14,68,105,107}\). Increased age has also been identified as a risk factor for CDI\(^{105}\); however, there was no significant difference in the median age between carriers of *C. difficile* and non-carriers. Ambulatory status appears to not affect *C. difficile* carriage, which is consistent with previous reports\(^{14,15}\).

### 5.3 Asymptomatic Carriage and Environmental Contamination

It is thought that asymptomatic carriage is an after effect of CDI, shedding of spores in stool, on skin, and into the environment occurring 1–4 weeks after CDI treatment; Sethi *et al.*, found that 56% of patients were asymptomatic carriers 1-4 weeks after treatment\(^{108}\). Limited data from 8 patients suggested that shedding might be much less common by 5–6 weeks after treatment\(^{87}\). Whilst the questionnaire used in this study asked whether the resident had had any diarrhoea within the previous six weeks, the majority of residents were currently taking laxatives or stool softeners, so any episode of diarrhoea may have gone undiagnosed. Some studies suggest that contact precautions be continued for up to one-month post CDI treatment\(^{87,108,109}\); whilst logical in theory, the isolation and stigma of contact precautions may have financial and psychological impact on the resident and ACF that outweigh the benefits.

Four of the six residents who had positive stool cultures also had positive results for environmental contamination in their room, which corresponds with previous studies;
Riggs et al., reported that asymptomatic carriers had significantly higher rates of skin and environmental contamination ($p$: 0.004) than non-carriers$^{31}$. Best et al. showed that airborne dispersal of *C. difficile* is possible$^{22}$, and Dubberke et al. found that those places which are more likely to be contaminated with faecal matter are those that are also more likely to harbour environmental *C. difficile*$^{110}$. Floors were more likely to be contaminated than doors, which corresponds with our findings in the pilot study (A Williams, unpublished results, 2013). This finding is biologically plausible, as faecal matter may be dispersed from toilets when flushing, showering or changing continence pads.

Current guidelines suggest using chlorine based disinfectants at 1000ppm when cleaning areas potentially contaminated with *C. difficile*$^{51}$. Pathogens that can colonise the gastrointestinal tract share similar risk factors and pathogenesis, and as such, infection prevention and control procedures may be put in place that may limit multiple pathogens, for example, both *C. difficile* and norovirus$^{111}$. Barker et al. found that in cleaning a surface with non-chlorine based detergent norovirus was still detectable on surfaces and could be spread via the wiping cloth to other surfaces. When a surface was treated with a combined hypochlorite/detergent formulation (with 5000ppm of available chlorine) applied for 1 minute, no norovirus could be detected on the surface and cross-contamination was not observed$^{112}$.

The current cleaning products used at the facilities contain the active ingredients of neodol 1-9 and sodium xylene sulphonate, both of which are ineffective in killing spores. Neodol is a non-ionic surfactant, whilst sodium xylene sulphonate is a wetting agent that helps a formula spread more easily and ensures efficient cleansing. Fawley et al. found that when comparing commonly used hospital cleaning agents and germicides, only chlorine-containing germicides inactivated *C. difficile* spores$^{82}$, whilst Best et al. found that hydrogen peroxide decontamination after deep cleaning with a detergent/chlorine agent, was highly effective for removing environmental *C. difficile* contamination$^{83}$. Deep cleaning was described as “intensive, prolonged, manual clean, which aimed to restore all surfaces to the best possible condition, leaving them free from ingrained dirt, debris and marks”$^{83}$.

### 5.4 Limitations

The main limitation of this study is the sample size. The small sample size has affected the analysis of risk factors for asymptomatic carriage of *C. difficile*, as the findings in this study do not correspond with findings from previous studies. A larger sample size may have enabled the identification of risk factors associated with asymptomatic *C. difficile* carriage, and may have determined if there were clear associations with prescription medications and carriage.
This study took place across six ACFs from one not-for-profit organisation in WA. Only 33.6% of the total number residents from the six ACFs participated and may not be truly representative of all residents within those facilities. This not-for-profit organisation has 13 ACFs across metropolitan Perth. During the design of the study it was decided by the organisation that their facilities north of the Swan River would be tested for convenience of travel time. Because of this, the findings from this study may not be representative of all the facilities within this organisation or of the ACF residential population of Australia in general. However, it should be noted that the care needs of the population residing within the facilities south of the Swan River are not different to those which participated in this study.

The method by which samples were collected was not random, but used a systematic selection based on whoever produced a faecal sample during the morning of collection. This may be biased against those who may not have bowel movements in the morning, or those who have infrequent bowel movements, however, the impact is most likely to be negligible. However, there may be confounding as those on stool softeners or laxatives were more likely to be included in this study. The mechanism in which stool softeners may impact C. difficile carriage rates is unknown, but may be related to osmotic changes in the gastrointestinal tract.

6. CONCLUSION

This study demonstrates there is undetected carriage of C. difficile in a sample of residents of the ACFs sampled in this study, and that asymptomatic carriers of C. difficile contaminate their environments more than those who do not carry C. difficile. These results may impact upon infection prevention and control measures within ACFs, as current routine cleaning procedures may not be adequate to prevent transmission of C. difficile by undetected carriage and shedding by asymptomatic carriers.
7. REFERENCES


54. Health Protection Agency UK. In: Inclusion criteria for reporting *C. difficile* infection to the surveillance system.


# 8. APPENDICES

## APPENDIX 1 – BRISTOL STOOL SCALE

**Bristol Stool Chart**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Separate hard lumps, like nuts (hard to pass)</td>
</tr>
<tr>
<td>Type 2</td>
<td>Sausage-shaped but lumpy</td>
</tr>
<tr>
<td>Type 3</td>
<td>Like a sausage but with cracks on the surface</td>
</tr>
<tr>
<td>Type 4</td>
<td>Like a sausage or snake, smooth and soft</td>
</tr>
<tr>
<td>Type 5</td>
<td>Soft blobs with clear-cut edges</td>
</tr>
<tr>
<td>Type 6</td>
<td>Fluffy pieces with ragged edges, a mushy stool</td>
</tr>
<tr>
<td>Type 7</td>
<td>Watery, no solid pieces. <strong>Entirely Liquid</strong></td>
</tr>
</tbody>
</table>
Dear Resident/Power of Attorney

This letter is to inform you of a clinical audit taking place within your residential care facility. Brightwater has established a relationship with UWA to perform this study in order to provide better care to our residents.

During the months of March and April, a faecal sample will be collected and tested for Clostridium difficile, a bacterium known to cause diarrhoea. Your current medications will be noted, especially any recent courses of antibiotics. These will be used to identify if there are any risks associated with certain medications and the diarrhoea caused by Clostridium difficile. None of the information provided to the research team will have any personal details (e.g. name, phone numbers), and so cannot be traced back to you/relative.

It is important to know that having the bacteria in your stool is not necessarily a bad thing; some people are known to be carriers of this bacterium without having any diarrhoea. If this bacterium C. difficile is found in your stool your care manager will know and be able to decide if any action is necessary. In most cases, no treatment will be required.

Your participation in this project is greatly appreciated, but completely up to you. If you have any questions about this study, or would prefer not to participate, please contact your care manager.

Thank you
APPENDIX 3 – INFORMATION FLYER FOR STUDY

COMMON QUESTIONS

What is Clostridium difficile?
Clostridium difficile or “C. diff” is a bacterium that can cause diarrhoea when and after you take antibiotics.

Where is it found?
C. difficile can be found in your gut, and in the environment.

How can I protect myself?
Good hand washing with soap and water.

Clostridium difficile
and you

For more information on this study or to opt-out, contact the care manager

This project is a collaborative effort between

Brightwater
THE UNIVERSITY OF WESTERN AUSTRALIA

Brightwater has teamed up with researchers at UWA to look at C. difficile to better protect everyone in our facilities.

Earlier this year the research team came and performed environmental testing. Now they are coming to find out how many residents carry the bacteria in their gut.

What will happening?
Stools samples and medical information will be collected by Brightwater staff and passed on to UWA researchers to look at the risk factors for getting this bacteria.

No personal information, such as names or contact details, will be passed on, so your privacy is completely protected.

Do I have to be a part of this?
No, it is voluntary. If you don’t want to take part, let the care manager at your site know.

Will having this bug make me sick?
Not necessarily though it may explain why you had diarrhoea recently.

Any other questions?
The research team will be coming in to the site to talk more about the project where you will be able to ask any questions.
APPENDIX 4 – CLINICAL QUESTIONNAIRE FOR STUDY

Clinical Questionnaire for *C. difficile* Study 

**Today’s date:____/____/_____**

**Section ONE - Patient Demographics:**

*This information will be gathered from the iCare printout*

Age: ______ Sex: □M □F Date of admission to facility: ___/___/_____

*The following two sections can be completed by the Care Worker*

**Section TWO - Functional Status:**

<table>
<thead>
<tr>
<th>Mobility</th>
<th>Ambulatory</th>
<th>Chair fast</th>
<th>Bedfast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>Continent</td>
<td>Incontinent</td>
<td>Don’t know</td>
</tr>
<tr>
<td>Bowel</td>
<td>Continent</td>
<td>Incontinent</td>
<td>Don’t know</td>
</tr>
</tbody>
</table>

**Section THREE - Devices/Aids**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

:Any other comments about the Resident (i.e. demeanour, anything unusual etc.): ____________________________________________

________________________________________________________________________________________________________

________________________________________________________________________________________________________

________________________________________________________________________________________________________

________________________________________________________________________________________________________

________________________________________________________________________________________________________

________________________________________________________________________________________________________

Thank you
Section 4: Medical Questions:
Does the resident currently have diarrhoea? □ Yes □ No □ Don’t know

Has the resident had diarrhoea within the last 6 weeks? □ Yes □ No □ Don’t know

Was a faecal specimen sent off for laboratory tests? □ Yes □ No □ Don’t know

If yes, what were the results? _____________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Did the resident receive treatment for the diarrhoea? □ Yes □ No □ Don’t know

Date of initiation of treatment: ___/___/____

Date of completion of treatment: ___/___/____

Compliance with treatment regime: □ Yes □ No □ Don’t know

Does the resident suffer from recurring/chronic infections of any sort? (e.g. UTI’s, wounds, fungal infections) □ Yes □ No

If yes, specify: _____________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Photocopy de-identified medicine chart for current drug use (apply unique identifier label)

Section FIVE – Hospitalisations
Has the resident been admitted to hospital in the past 3 months: □ Yes* □ No □ Don’t know

If yes, for how long was the resident in hospital? __________________________________________

* Discharge summary is required

Section SIX - Procedures
Has the resident undergone any of the following procedures in the past 4 weeks?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Surgery</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Enema</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Endoscopy (specify from medical notes)</td>
</tr>
</tbody>
</table>
Chapter 3

Evaluation of the Healthcare Infection Surveillance Western Australia System
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PROLOGUE

MY ROLE

My role in this study was as the key researcher, in which I designed the study, co-ordinated and conducted surveys, entered and analysed data and wrote the report which was provided to the stakeholders. I worked with the staff of the Healthcare Associated Infection Unit at the Communicable Disease Control Directorate for this project.

LESSONS LEARNED

Through this evaluation project, I learnt a lot about healthcare-associated infections, infection prevention and control programs, and the importance of a well-structured and solid surveillance system. I learnt about survey design, data analysis and interpretation of qualitative data, public health writing skills and collaboration with stakeholders.

PUBLIC HEALTH IMPACT

The results from this evaluation have been used to assist in the bid to Treasury to upgrade patient management system software to automated surveillance technology across WA, which will impact infection prevention and control practices within WA healthcare facilities.

ACKNOWLEDGEMENTS

Rebecca McCann, Alison Peterson, Simone Tempone, Dr Paul Armstrong, and the HISWA stakeholders
SUMMARY OF EVALUATION

OVERVIEW

The Healthcare Infection Surveillance of Western Australia (HISWA) system is a statewide surveillance system that collects data on 12 indicators and four denominators relating to healthcare-associated infections (HAIs) or exposures in healthcare facilities (HCFs) across Western Australia.

This evaluation of the HISWA system was performed using the US Centers for Disease Control and Prevention (CDC) guidelines for evaluating a public health surveillance system. This evaluation coincides with the proposal for upgrading HISWA to a standardised automated system for capturing infection surveillance data, and so informs the development of that proposal.

ATTRIBUTES

CONFIDENTIALITY

HISWA has appropriate technology in place for secure transmission of patient data. Rates are published as aggregates and patient-identified data are not released.

USEFULNESS

HISWA data are used at HCFs, state and national level for the identification of trends, reporting to appropriate authorities and publications by the Healthcare Associated Infection Unit (HAIU) and national bodies. Data are also used to inform clinicians and administrators at HCFs, direct health policies, assess the impact of interventions, guide antimicrobial stewardship practices, conduct research, and in scientific publications.

SIMPLICITY

The current structure of data flow through HISWA is straightforward; however, data collection at HCFs for submission to HISWA is complex and time-consuming, utilising several sources for information, with no consistent processes across all HCFs.

FLEXIBILITY

The HISWA system has the capacity to be flexible if small changes to the database are required. However, if large changes are required, the system is inflexible due to time and cost restraints.
DATA QUALITY

The quality of data collected in HISWA is based upon three key factors: meeting the definition of a HAI for the specific indicator, internal validation of data collected by the HAIU and zero-reporting of data.

ACCEPTABILITY

The overall HCF participation rate for submission of data to HISWA from both public and private facilities is 97%. Public facilities and private facilities contracted to treat public patients are mandated to participate in HISWA as written in the WA Health Operational Directive 0527/14. Of the 18 private HCFs who are not mandated to submit data, 15 facilities voluntarily submit data to HISWA.

SENSITIVITY AND POSITIVE PREDICTIVE VALUE

The overall sensitivity and positive predictive value (PPV) for the HISWA system has not been evaluated. Informal validation exercises currently involve those cases for which laboratory diagnosis is performed through PathWest Laboratory Medicine, and as a result, the sensitivity and PPV of HISWA cannot be accurately calculated. In order for both sensitivity and PPV to be calculated for the entire HISWA system, a large-scale evaluation of these two attributes would have to be performed. This would be expensive and labour intensive, and may not be beneficial overall.

REPRESENTATIVENESS

Approximately 92% of all beds in WA are within HCFs that submit data to HISWA. This indicates that the HISWA system is highly representative of the burden of HAIs across WA HCFs.

TIMELINESS

Two main components affect the timeliness of the HISWA system – the data collection and entry and the publication of reports. HISWA is not a timely system; however this is not a necessarily a problem, as most infection prevention and control (IPC) activities do not require real-time reporting.

STABILITY

The HISWA database entry is web-based and any planned maintenance work is performed out-of-hours. The introduction of automated surveillance technology (AST) would replace manual data collection and some out-dated IPC technologies currently in use at some WA HCFs.
RESOURCES FOR SYSTEM OPERATION

In 2012-13, IPC professionals (IPCPs) spent more than 2,850 hours and over $190,000 of attributable costs investigating HAI events for data submission to HISWA. This is a gross underestimation of the real amount of time and money spent investigating HAIs as only 11 infections are reported to HISWA, whilst IPC teams would investigate other HAI events that are not reported to HISWA.

RECOMMENDATIONS

1. Automated harvesting and reporting of data
2. Addition of new indicators
3. Update the HISWA “Terms of Reference”
4. Change of data analysis and reporting graphs to allow for better comparison with other jurisdictions
5. For greater representativeness, HCFs with beds less than 25 beds to report independently, or to a regional centre to report on their behalf
6. Increased capacity of HAIU for analysing, reporting, timeliness and use of data in publications by increasing staff and technology
## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Text</th>
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<tbody>
<tr>
<td>ABF/M</td>
<td>Activity Based Funding/Management</td>
</tr>
<tr>
<td>ACHS</td>
<td>Australian Council for Healthcare Standards</td>
</tr>
<tr>
<td>ACSQHC</td>
<td>Australian Commission on Safety and Quality in Health Care</td>
</tr>
<tr>
<td>AIHW</td>
<td>Australian Institute for Health and Welfare</td>
</tr>
<tr>
<td>ANZICS</td>
<td>Australia and New Zealand Intensive Care Society</td>
</tr>
<tr>
<td>AST</td>
<td>Automated Surveillance Technology</td>
</tr>
<tr>
<td>BSI</td>
<td>Bloodstream infections</td>
</tr>
<tr>
<td>CABG</td>
<td>Coronary artery bypass grafts</td>
</tr>
<tr>
<td>CAI</td>
<td>Community-associated infection</td>
</tr>
<tr>
<td>CDC</td>
<td>US Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>CDCD</td>
<td>Communicable Disease Control Directorate</td>
</tr>
<tr>
<td>CDI</td>
<td><em>Clostridium difficile</em> infection</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence interval</td>
</tr>
<tr>
<td>CLABSI</td>
<td>Central line-associated bloodstream infection</td>
</tr>
<tr>
<td>COAG</td>
<td>Council of Australian Governments</td>
</tr>
<tr>
<td>CRE</td>
<td>Carbapenem-resistant <em>Enterobacteriaceae</em></td>
</tr>
<tr>
<td>DG</td>
<td>Director General</td>
</tr>
<tr>
<td>EAG</td>
<td>Expert Advisory Group</td>
</tr>
<tr>
<td>eICAT</td>
<td>electronic Infection Control Assessment Technologies</td>
</tr>
<tr>
<td>ESBL</td>
<td>Extended spectrum beta-lactamase</td>
</tr>
<tr>
<td>HAI</td>
<td>Healthcare-associated infection</td>
</tr>
<tr>
<td>HAIU</td>
<td>Healthcare Associated Infection Unit</td>
</tr>
<tr>
<td>HCF</td>
<td>Healthcare facility</td>
</tr>
<tr>
<td>HD-BSI</td>
<td>Haemodialysis-access bloodstream infection</td>
</tr>
<tr>
<td>HICWA</td>
<td>Healthcare Infection Council of Western Australia</td>
</tr>
<tr>
<td>HIN</td>
<td>Health Information Network</td>
</tr>
<tr>
<td>HISWA</td>
<td>Hospital Infection Surveillance Western Australia</td>
</tr>
<tr>
<td>ICD-10-AM</td>
<td>International Classification of Diseases - version 10 - Australian Modification</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive care unit</td>
</tr>
<tr>
<td>IDM</td>
<td>Information development and management</td>
</tr>
<tr>
<td>IDSA</td>
<td>Infectious Diseases Society of America</td>
</tr>
<tr>
<td>IPC</td>
<td>Infection prevention and control</td>
</tr>
<tr>
<td>IPCP</td>
<td>Infection prevention and control professional</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
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<tr>
<td>Acronym</td>
<td>Full Text</td>
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<tr>
<td>---------</td>
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</tr>
<tr>
<td>MRO</td>
<td>Multi-resistant organism</td>
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<tr>
<td>MRSA</td>
<td>Methicillin-resistant <em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>MSSA</td>
<td>Methicillin-susceptible <em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>NEAT</td>
<td>National emergency access target</td>
</tr>
<tr>
<td>NHHI</td>
<td>National Hand Hygiene Initiative</td>
</tr>
<tr>
<td>NHPA</td>
<td>National Health Performance Authority</td>
</tr>
<tr>
<td>NHSN</td>
<td>National Healthcare Safety Network</td>
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<tr>
<td>NSQHS</td>
<td>National Safety and Quality Health Service</td>
</tr>
<tr>
<td>OD</td>
<td>Operational Directive</td>
</tr>
<tr>
<td>OE</td>
<td>Occupational exposure</td>
</tr>
<tr>
<td>PAQ</td>
<td>Performance and Quality</td>
</tr>
<tr>
<td>PDS</td>
<td>Post-discharge surveillance</td>
</tr>
<tr>
<td>PPV</td>
<td>Positive predictive value</td>
</tr>
<tr>
<td>SABSI</td>
<td><em>Staphylococcus aureus</em> bloodstream infection</td>
</tr>
<tr>
<td>SHEA</td>
<td>Society for Healthcare Epidemiology of America</td>
</tr>
<tr>
<td>SSI</td>
<td>Surgical site infections</td>
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<tr>
<td>VAP</td>
<td>Ventilator-associated pneumonia</td>
</tr>
<tr>
<td>VRE</td>
<td>Vancomycin resistant enterococci</td>
</tr>
<tr>
<td>WA</td>
<td>Western Australia</td>
</tr>
<tr>
<td>WACHS</td>
<td>Western Australia Country Health Service</td>
</tr>
<tr>
<td>WAMRO EAG</td>
<td>Western Australia Multi-Resistant Organism Expert Advisory Group</td>
</tr>
<tr>
<td>WebPAS</td>
<td>Web-based patient administration system</td>
</tr>
<tr>
<td>TMS</td>
<td>Theatre management system</td>
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</tbody>
</table>
# LIST OF TERMS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACCESS</strong></td>
<td>Australian Collaborating Centre for Enterococcus and Staphylococcus Species (ACCESS) Typing and Research</td>
</tr>
<tr>
<td><strong>Contributor</strong></td>
<td>A person, typically an IPCP or data manager, who contributes data to HISWA for a HCF</td>
</tr>
<tr>
<td><strong>eICAT</strong></td>
<td>Software used by the IPCP in WA to store and analyse infection control data including surveillance data. It was developed by Qld health and purchased by WA Health in 2000. It is not an integrated system and requires manual data entry into databases. It no longer has external IT supports.</td>
</tr>
<tr>
<td><strong>HCare, IMS, TMS, TOPAS and WebPAS</strong></td>
<td>Various patient management systems used in WA hospitals that hold patient demographic data and medical information</td>
</tr>
<tr>
<td><strong>Healthcare-associated infection (HAI)</strong></td>
<td>An infection acquired by a patient as a result of the provision of healthcare</td>
</tr>
<tr>
<td><strong>Indicator</strong></td>
<td>A standardised measure to compare health status and health system performance</td>
</tr>
<tr>
<td><strong>Infection prevention and control professional (IPCP)</strong></td>
<td>A professional, usually a nurse or epidemiologist, who works to prevent and control infections within HCFs</td>
</tr>
<tr>
<td><strong>PathWest Laboratory Medicine WA</strong></td>
<td>The state public sector pathology and laboratory service in WA</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

1.1 HEALTHCARE ASSOCIATED INFECTION SURVEILLANCE IN AUSTRALIA

Surveillance and prevention of HAIs in Australia are coordinated within each jurisdiction; Australia does not have a uniform surveillance approach. As such, benchmarking and comparison of incidence and prevalence of HAIs are hard to perform.

The first jurisdiction to implement a state-wide surveillance program was New South Wales where a program was piloted from 1998 until 2000. Queensland followed in 2000 with the Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP) program, then Victoria in 2002 with the Victorian HAI surveillance system (VICNISS). The Northern Territory has been collecting HAI incidence data informally for the past 20 years, and has only recently commenced jurisdictional reporting to NT Health. Only major hospitals in South Australia report HAI data to the state health department. The Tasmanian Infection Prevention and Control Unit (TIPCU) was established in 2008 and conducts state-wide surveillance.

In 2003, the National Strategy to Address Healthcare Associated Infections was published by the Australian Council for Safety and Quality in Healthcare and was endorsed by all state and territorial health ministers. In 2009 the Australian Commission for Quality and Safety in Health Care (ACSQHC) was established and, with it, mandatory reporting of all *Staphylococcus aureus* bloodstream infections (SABSI) by public hospitals began. In 2011, hospital-identified *Clostridium difficile* infections (CDI) and central line-associated bloodstream infections (CLABSI) were added as indicators to be reported nationally.

National reporting of hand hygiene compliance, SABSI and hospital-identified CDI has been mandatory under the National Healthcare Agreement since 2009. Data are reported by the states and territories to the Australian Institute of Health and Welfare (AIHW), which provides state-wide hospital data to the Council of Australian Governments (COAG) reform meetings, and to the National Health Performance Agency (NHPA) for publishing hospital identified SABSI rates on the MyHospital website as a quality performance indicator.

1.2 HEALTHCARE INFECTION SURVEILLANCE IN WESTERN AUSTRALIA

The HISWA system first commenced in 2005, with data voluntarily submitted by both public and private healthcare facilities (HCFs) to the Communicable Disease Control Directorate (CDCD) of the Department of Health WA. Mandatory reporting of HAI events was introduced in 2007 for all public HCFs and those private HCFs contracted to provide
care for public patients in WA, as stipulated in the Operational Directive [OD]: *Healthcare Infection Surveillance in Western Australia OD 0527/14*. Other private HCFs voluntarily contribute data to HISWA.

In 2007, the HAIU was established within the CDCD in the Department of Health WA. The HAIU is the co-ordinating body for the HISWA system. The Healthcare Infection Council of WA (HICWA), consisting of senior medical and nursing personnel, was founded in 2007 by the HAIU to provide executive governance and accountability for HAIAs across the health system in making policy recommendations relevant to the monitoring, prevention and control of HAIAs across all of WA Health5,6.

**1.3 CURRENT STRUCTURE OF HISWA**

Data are collected on 11 HAI events as well as occupational exposures, and four denominator categories in HISWA as outlined in Tables 1a and 1b. The nine mandatory indicators and two voluntary indicators reported to HISWA are outlined in the OD 0527/14 Appendix A: HISWA Program and Reporting Requirements4.

**Table 1a.** Indicators (numerators) collected in HISWA

<table>
<thead>
<tr>
<th>Indicators</th>
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</thead>
<tbody>
<tr>
<td>Surgical site infections following hip arthroplasty</td>
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<tr>
<td>Surgical site infections following knee arthroplasty</td>
</tr>
<tr>
<td>Surgical site infections following elective or emergency caesarean section</td>
</tr>
<tr>
<td>All methicillin-resistant <em>Staphylococcus aureus</em> (MRSA) infections</td>
</tr>
<tr>
<td>Hospital-identified <em>Clostridium difficile</em> infections (CDI)</td>
</tr>
<tr>
<td><em>S. aureus</em> bloodstream infections (SABSI)</td>
</tr>
<tr>
<td>Haemodialysis access-associated bloodstream infections (HD-BSI)</td>
</tr>
<tr>
<td>Central-line associated bloodstream infections (CLABSI) in adult intensive care units (ICU)</td>
</tr>
<tr>
<td>CLABSI in Haematology unit</td>
</tr>
<tr>
<td>CLABSI in Oncology unit</td>
</tr>
<tr>
<td>Vancomycin-resistant Enterococci (VRE) sterile site infections</td>
</tr>
<tr>
<td>Occupational exposures</td>
</tr>
</tbody>
</table>

**Table 1B.** Denominators collected in HISWA

<table>
<thead>
<tr>
<th>Denominators</th>
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</thead>
<tbody>
<tr>
<td>Bed-days and separations (multi-day and same-day)</td>
</tr>
<tr>
<td>Central line-days (central, peripheral)</td>
</tr>
<tr>
<td>Haemodialysis patient-months</td>
</tr>
<tr>
<td>Number of surgical procedures (hip and knee arthroplasty, caesarean sections)</td>
</tr>
</tbody>
</table>
Other HAIs that frequently occur but are not collected as indicators by HISWA include urinary tract infections (UTIs), bloodstream infections (BSI) with organisms other than S. aureus, ventilator-associated pneumonia (VAP), surgical site infections for other procedures such as coronary artery bypass graft (CABG) infections, and infections from multi-resistant organisms (MROs) including carbapenem-resistant Enterobacteriaceae (CREs) and extended-spectrum beta-lactamase (ESBL) producing organisms. These infections can also increase the morbidity and/or risk of mortality to the patient and the burden upon the healthcare system.

The current structure and flow of data through HISWA are straightforward and is illustrated in Figure 1. Infection prevention and control teams within HCFs contribute data to HISWA. The HAIU team analyses data for the State and generates reports that are sent to members of HICWA, WAMRO and to the contributors. Validation of data is performed by comparison of data from PathWest, TOPAS/WebPAS and the ACCESS database, and in discussions with contributors. The data are the property of the individual contributing HCF and are not used without their permission. HISWA complies with the WA Health OD 0487/14 Data Stewardship and Custodianship Policy.

1.4 The Public Health Importance of HAIs

Those people who attend a HCF typically do so as they are undergoing a procedure or treatment which puts them at a greater risk of contracting a HAI. Underlying illness i.e. the reason for needing a procedure or treatment also increases the risk of contracting a HAI. There are several factors that have influence on an individual’s risk of developing a HAI including:

- their immune status at the time of exposure – those who are receiving treatment at HCFs are more likely to be immune-compromised
- their age – neonates and the elderly are more susceptible to HAIs
- their health status – underlying conditions such as diabetes or cancer, or being a smoker increase the risk of contracting a HAI
- the virulence of the infectious agent and the degree to which it is resistant to antimicrobial agents

There is also a range of other risk factors, such as the presence of an indwelling devices, invasive procedures, treatment regimens, and the length of stay in a HCF.
Figure 1. Flow of data through HISWA and reports produced by HAIU.
Within a HCF, patients may be exposed to infectious agents from two sources, from themselves (endogenous infections), or from other people, instruments, equipment, or the environment (exogenous infections) through contact (direct, indirect), from droplet and airborne spread. Endogenous infections may be preventable by decolonizing the patient, antibiotic prophylaxis and adequate wound care, whilst exogenous infections may be prevented through infection prevention strategies, such as isolation and contact precautions, aseptic technique, hand hygiene compliance and environmental cleaning.8

The impact of HAIs includes an increased risk of morbidity and mortality, reduced quality of life, and prolonged hospital stays with additional bed-days and cost of consumable items. HAIs are a considerable burden for both the individual patient and the health system.9 It is estimated that each year in Australia approximately 200,000 patients contract HAIs and occupy more than 2 million additional hospital bed days during treatment.10,11 In WA, it was estimated that in the 2012/13 reporting period, the cost of HAIs reported to HISWA was more than $12 million and contributed an additional 5,000 bed-days.12,13

Not only is the treatment of HAIs an economic burden, but the prolonged use of antibiotics that are often required to treat HAIs increases the risk of resistance to the antibiotic developing. Resistance to antibiotics occurs as a natural mechanism of survival for bacteria against selective pressures, such as the prolonged and/or unnecessary use of broad-spectrum antibiotics in healthcare and agriculture.14 This encourages the production or acquisition of resistance determinants. Resistance to multiple antibiotics occurs, resulting in MROs, such as MRSA, VREs and ESBLs. These MROs are known to increase morbidity and mortality, length of stay and overall cost of treatment compared to those that are susceptible to antibiotics. Neidell et al., found that infections caused by MROs cost significantly more than infections with susceptible organisms ($25,573; 95%CI $9,331–$41,816 and $15,626; 95%CI, $4,339–$26,913, respectively) and Cosgrove estimated infections due to MROs cost approximately $6,000–$30,000 more to treat than those with non-resistant organisms.15,16 In WA, both MRSA and sterile site VRE infections (both important MROs) are indicators collected by HISWA and, since the early 1980s, MRSA has been a notifiable condition. Since 2005-6, there has been a significant decrease in the rate of MRSA infections reported to HISWA, from 0.95 infections per 10,000 bed-days in 2005-06 to 0.74 infections per 10,000 bed-days in 2012-13 (p = <0.01, mid-p exact) (Figure 2). CRE infections are not common in WA and, as such, are currently monitored by a separate mechanism via the HAIU and Western Australia Multi-Resistant Organism Expert Advisory Group (WAMRO EAG).
Surveillance of HAIs can also be used to assess the quality of care and IPC methods provided within a HCF\textsuperscript{17}. Collecting data on bloodstream infections may improve quality of care received in hospitals as it can identify areas of improvement in preventing HAIs, and the associated systemic problems within HCFs\textsuperscript{18}. SABSI data reported to HISWA are sent annually to the Performance and Quality Division (PAQ) of WA Health for activity-based management and funding (ABM/F).

In order to prevent HAIs, it is important to know how many infection events there are. An effective surveillance system is central to HCF's IPC teams' ability to understand the effectiveness of preventative measures currently in place\textsuperscript{19}. It is estimated that up to 70\% of all HAIs are preventable with appropriate infection prevention and control measures\textsuperscript{20}, which include a robust surveillance system. The peak professional bodies for IPC in the US, along with the CDC have come together to suggest that HAIs can be eliminated, as has been achieved for smallpox, and is hoped for measles and polio, by the "implementation of evidence-based practices, alignment of financial incentives, the closing of knowledge gaps, and the acquisition of information to assess progress and to enable response to emerging threats"\textsuperscript{21}. Whilst Umscheid et al. argue that the goal of preventing 100\% of HAI events is not practical, the comprehensive implementation of strategies aimed at achieving this goal could prevent hundreds of thousands of HAI events\textsuperscript{22}. As stated in the Western Australian Strategic Plan for Safety and Quality in Healthcare 2008-2013, "put simply, preventable adverse events create an additional unnecessary resource burden on an already strained health system and its people" and that after taking into account the cost of preventative action, WA Health could save $170 million annually in preventing HAI events\textsuperscript{23}.

\textbf{Figure 2}. Number and rate of MRSA infections reported to HISWA, 2006/06 – 2012/13. Data obtained from HISWA database, July 2014

[Diagram showing number and rate of MRSA infections per 10,000 bed-days from 2005-06 to 2012-13, with separate bars for ICU, Non-ICU, and the rate graph showing a decline over time.]
1.5 PURPOSE AND OBJECTIVES

"The evaluation must first determine whether the surveillance system meets its primary objectives" \(^9\)

1.5.1 PURPOSE

HISWA was established to undertake standardised monitoring of HAIs in WA, in response to the National Strategy to Address Healthcare Infections, 2003. Whilst there is no clearly defined purpose of HISWA written in one overarching document, there are several documents and websites which describe why there is a system\(^6,24,25\). These points include:

1. to ensure all WA hospitals utilise standardised definitions and methodology
2. to ensure the validity of data through formal and informal validation exercises
3. to provide support to surveillance personnel contributing data to HISWA
4. to reflect the importance of HAIs within the WA Clinical Governance Framework
5. to provide high quality comparative data
6. to help inform system-level priority
7. to evaluate prevention programs in WA

1.5.2 OBJECTIVES

The objectives of the HISWA program are to\(^5,24,25\):

1. identify trends and engage clinicians to review clinical care and processes to minimise infection risks
2. ensure activities are aligned, where possible, with Australian and international surveillance programs to allow for relevant external benchmarking
2. EVALUATION

2.1 RATIONALE FOR EVALUATION

Surveillance is the cornerstone of prevention of healthcare associated infections.\(^9\)

Whilst the HAIU recommends that periodic internal validation of hospital level data by the HCF is performed to ensure the continued validity of data submitted to HISWA (Appendix 1), an overall evaluation of the entire HISWA system has not been performed since the inception of the program in 2005. Evaluating a surveillance system ensures that the conditions and diseases of public health importance are being monitored efficiently and effectively, and that data used for public health action results in reduced morbidity and mortality, and overall improvement of health.\(^5\) By evaluating HISWA, we can identify any areas of improvement required to ensure robust surveillance of HAIs across WA HCFs. This evaluation also coincides with the proposal of upgrading HISWA and introducing a standardised AST system for the capturing of infection surveillance data.

To effectively reduce the rates of HAIs, a multi-faceted approach is required, which includes an efficient surveillance system. Prevention of HAIs is the responsibility of all who care for patients, and can cost less than treating such infections. Surveillance of HAIs underpins quality improvement in the HCFs.\(^26\)

2.2 ENGAGING STAKEHOLDERS

System stakeholders should be engaged in a discussion to ensure that the evaluation of a system addresses appropriate questions and assesses pertinent attributes and that its findings will be acceptable and useful.\(^9\)

The stakeholders of HISWA include those who collect and enter data, those who analyse and report from the data, and those who receive reports from the HAIU. Table 2 shows the groups of potential stakeholders involved with HISWA and the activities in which each group of stakeholders were invited to participate in for this evaluation.
Table 2. Stakeholder groups of the HISWA System

<table>
<thead>
<tr>
<th>Groups</th>
<th>Method of Consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributors</td>
<td>Online survey participation¹</td>
</tr>
<tr>
<td>CDCD – HAIU</td>
<td>Consultation throughout planning and evaluation stages</td>
</tr>
<tr>
<td></td>
<td>In-depth interviews about system</td>
</tr>
<tr>
<td>WAMRO EAG</td>
<td>Email with four questions</td>
</tr>
<tr>
<td>HICWA</td>
<td>Email with four questions</td>
</tr>
<tr>
<td>WACHS Executives</td>
<td>Online survey with four questions</td>
</tr>
</tbody>
</table>

¹ Survey questions in Appendix 2, summary of answers in Appendix 3

2.2.1 Online Survey of Contributors

Contributors to HISWA - generally nurses, laboratory scientists, or data entry personnel – were invited to participate in an online survey questioning their experience with the HISWA system (Appendix 2). The survey was constructed in consultation with the CDCD-HAIU.

From the 78 contributors contacted, 37 completed the survey, giving an overall response rate of 47%. There was no difference in the response rate between metropolitan and rural healthcare services (43.3% metropolitan, 42.3% rural, \( p = 0.65 \)) or in the representation of respondents from public and private healthcare facilities (43.8% public, 34.6% private, \( p = 0.25 \)). Reminder emails were sent out twice to participants in each survey, which may have increased the response rate. Results from this survey are discussed throughout this report, and a summary of the responses is in Appendix 3.

2.2.2 Email Survey of Those Who Receive Reports

An email asking the following four questions was sent to 30 WAMRO EAG and HICWA Executive members who regularly receive HISWA reports:

1. How does your facility use data generated from HISWA?
2. Do you find the HISWA reports useful? Why/why not?
3. Is HISWA meeting its objectives?
4. Are there any other indicators you believe would be useful for HISWA to collect and report on?

The response rate for this survey was very poor (~20%); this may be due to the time constraints of those asked to respond. An online survey with the four questions was also sent to the Directors of WACHS who receive HISWA reports. The responses were anonymous and the response rate was 36.7% (\( n = 30 \)). Results from this survey are discussed throughout this report, whilst a summary of the responses is in Appendix 3.
3. ATTRIBUTES

This evaluation was based upon the CDCs *Updated Guidelines for Evaluating Public Health Surveillance Systems*. Attributes are the characteristics which make up a surveillance system\(^9\).

3.1 CONFIDENTIALITY

There is a need to balance between having adequate data to inform public health practice and the ability to protect confidentiality of personal health information\(^9\).

Whilst individual patient data are collected and entered into the HISWA system, confidentiality of individual events is maintained as no identifiable patient data are released, and only de-identified aggregated hospital data are released for reports. The security of the online HISWA entry is made up of several layers, combining to provide an industry recognised standard of security. These layers include several safety measures as outlined in Table 3\(^{27}\).

**Table 3. Security measures for HISWA online data entry website, WA, 2013**

<table>
<thead>
<tr>
<th>Security measure</th>
<th>Protection provided</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>SSL (Secure Sockets Layer)</em></td>
<td>Provides a vehicle for encrypting data transfer between the application and the back end database; essentially all data requests and updates are encrypted before being transferred across the network/ internet so that any data that are intercepted will be unreadable.</td>
</tr>
<tr>
<td>Authentication via username and password</td>
<td>Ensures only authenticated users can access the system.</td>
</tr>
<tr>
<td><em>Strong password policy</em></td>
<td>Implementing a strong password policy ensures user passwords are harder to decipher.</td>
</tr>
<tr>
<td><em>Data Validation</em></td>
<td>All data entered into the system are validated for legitimacy. If any data fails to conform to predetermined formats, then that request will be denied.</td>
</tr>
</tbody>
</table>
3.2 USEFULNESS

Whether useful actions are taken as a result of the analysis and interpretation of the data from the surveillance system

A public health surveillance system is useful if it contributes to the prevention and control of adverse health-related events. Data generated from HISWA is used to prevent HAI events at hospital, state-wide and national levels.

At all three levels, the following of trends over time is the main use of the data generated by HISWA. The data can be used to convince clinicians and administrators of potential problems, direct hospital policy, assess the impact of interventions, guide antimicrobial stewardship practices, conduct research, and make comparisons of rates and practices within and between HCFs. Ultimately, they are used to reduce rates of HAI events in WA HCFs.

3.2.1 HEALTHCARE FACILITIES

Whilst it may seem straightforward, it is the assessment of the effect of the prevention and control programs implemented by IPC teams that make surveillance systems useful. The HISWA system is useful for HCFs as it allows for the benchmarking of HAI rates in their facility and evaluation of IPC programs within the HCF. Data collated in HISWA can provide an incentive for change leading to an improvement in the quality of care and the reduction of HAI events.

The majority of respondents commented that the system could be improved by adding the ability to amend one’s own errors and incorporating the capacity to extract monthly data for one's own HCF after data submission, without having to contact the HAIU. However, these functionalities already exist within the current HISWA structure, and are documented in the HISWA Users Database Manual. The HAIU is frequently reminding IPCPs of these capabilities (HAIU Staff, personal comm., March 2013). Infection and exposure data can be modified up until the finalisation of the data at the end of the month via the HISWA website, after which the information can only be sighted. Changes to finalised data can only be made through communicating with the HAIU. HISWA contributors can generate basic line-listings of infections and/or denominators over a set period of time, which can be exported into Excel. A maximum of 10,000 records can be extracted at any one time.

The data from HISWA have been used to implement changes to IPC practices across WA HCFs including increased hand hygiene auditor training and increased education in the
importance of hand hygiene compliance, highlighting the need for education sessions of aseptic techniques, (W McIntosh, personal comm., January 2014).

3.2.2 STATE-WIDE

The HAIU collates HISWA data on a monthly basis. A quarterly aggregated state-wide rate is reported for each of the indicators, allowing the tracking of trends over time. HISWA data are also used to inform the HAIU for training and education of IPCPs and in the development of resources for HAI prevention strategies. For example, trends noticed in HISWA, such as a reduction in data quality, or an increase in notifications of one indicator type, would be addressed with IPCPs at the relevant HCF, or at the HISWA quarterly forum.

Since the 2005-06 reporting year, the rates of reported CLABSI in adult ICU in WA have decreased significantly ($p < 0.001$) suggesting a positive effect of the HISWA system (Figure 3a). However, this cannot be directly attributed to HISWA alone, as monitoring the effect of infection prevention measures is limited. Figures 3a-f demonstrates the output of data from HISWA for various indicators with the number of infections reported, and a rate of infections per appropriate denominator. For each indicator there is a decrease in the rate of infections since 2005-06, with some decreases more distinct than others. The rate of CDI notifications has significantly increased; however, it needs to be noted that these are hospital-identified infections, which include both community and healthcare-associated infections.

Figure 3a. Notifications and rate of CLABSI reported to HISWA, 2005 – 2013. Rates of CLABSI reported to HISWA have decreased significantly, from 2.41 per 1,000 line days in 2005-06 to 0.46 per 1,000 line days in 2012-13 ($p < 0.001$). Data obtained from HISWA database, July 2014
Figure 3b. Notification and rate of SSI reported to HISWA, 2005-2013. Rates of Hip SSIs reported to HISWA have reduced from 2.18 infections per 100 procedures in 2005-06 to 1.24 infections per 100 procedures. Knee SSIs have also reduced, from 1.55 infections per 100 procedures in 2005-06 to 0.78 infections per 100 procedures in 2012-13 (p < 0.001). Data obtained from HISWA database, July 2014.

Figure 3c. Notifications and rate of MRSA reported to HISWA, 2005-2013. The rate of MRSA infections reported to HISWA has decreased significantly, from 0.95 per 10,000 bed-days in 2005-06 to 0.74 per 10,000 bed-days in 2012-13 (p < 0.001). Data obtained from HISWA database, July 2014.
Figure 3d. Notifications and rate of HD-BSI reported to HISWA, 2005 – 2013. The rate of HD-BSI reported to HISWA decreased significantly, from 1.12 per 100 patient-months in 2005-06 to 0.38 per 100 patient-months in 2012-13 (p <0.001). Data obtained from HISWA database, July 2014

Figure 3e. Notifications and rate of hospital-identified CDI reported to HISWA, January 2010 - June 2013. The rate of CDI reported to HISWA has significantly increased, from 1.47 per 10,000 bed-days in quarter 1 of 2010, to 3.36 per 10,000 bed-days in quarter 2 in 2013. CDI notifications peaked in quarter 1 of 2012, with 5.28 reports per 10,000 bed-days (p <0.001). Data obtained from HISWA database, July 2014
Figure 3f. Notifications and rate of SABSI reported to HISWA, 2007 – 2013. The rate of SABSI has decreased significantly, from 0.94 per 10,000 bed-days in 2007-08 to 0.68 in 2012-13 (p <0.001). Data obtained from HISWA database, July 2014

3.2.3 NATIONAL

The HAIU reports HISWA SABSI data to the AIHW, as it is a mandatory requirement under the National Healthcare Agreement. The NHPA uses the SABSI data submitted to AIHW as a quality indicator for effectiveness in safety and quality of healthcare provided in major and large hospitals. The NHPA publishes national aggregated data on the MyHospital website, where the public can view SABSI data for major and large hospitals in each jurisdiction\textsuperscript{26}. National data were also useful in forming policy and standards, such as Standard 3 of the National Safety and Quality Health Service (NSQHC) Standards. The NSQHC Standards were developed by the Australian Commission on Safety and Quality in Healthcare (ACSQHC) to protect the public from harm and to improve the standard of quality of care provided by HCFs. The NSQHC Standard 3 provides a quality assurance mechanism to ensure minimum standards of safety and quality are met and a quality improvement mechanism which aims to aid HCFs in attaining quality development goals.

HCFs that participate in HISWA meet the NSQHC standard section 3.2 “Undertaking surveillance of healthcare-associated infections” under the criterion “Governance and systems for infection prevention, control and surveillance”, as the action requirements of ensuring surveillance system is in place. Surveillance data monitoring is also a requirement of participation in HISWA\textsuperscript{30}. 
3.2.4 Feedback from Stakeholders

All stakeholders were asked "Is the HISWA system meeting its objectives, as described in the HISWA Surveillance Manual?" Almost 90% of the end-users and the majority of those who received HISWA reports agreed that the HISWA system is meeting its objectives as described in the HISWA surveillance manual (n= 33).

3.2.5 Data Used Elsewhere

Data generated in HISWA have previously been used in scientific publications (Table 4). In discussing the potential of publishing further articles using HISWA data, the limited resources within the HAIU were stated as the main factor why more papers have not been published (HAIU staff, personal comm., April 2014).

Table 4. List of peer reviewed publications wherein data from HISWA have been used, 2008-2014.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Journal</th>
<th>Year</th>
<th>Vol(Is)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Gessel, H.</td>
<td>Measuring the incidence of <em>Clostridium difficile</em>-associated diarrhoea in a group of Western Australian hospitals</td>
<td>Healthcare Infect</td>
<td>2008</td>
<td>13(2)</td>
<td>56</td>
</tr>
<tr>
<td>Goggin LS, van Gessel H, McCann RL, Peterson AM, Van Buynder PG.</td>
<td>Validation of surgical site infection surveillance in Perth, Western Australia</td>
<td>Healthcare Infect</td>
<td>2009</td>
<td>14(3)</td>
<td>101</td>
</tr>
<tr>
<td>Dailey L.</td>
<td>Two years of surgical site infection surveillance in Western Australia: analysing variation between hospitals</td>
<td>Healthcare Infect</td>
<td>2009</td>
<td>14(2)</td>
<td>51</td>
</tr>
<tr>
<td>Tracey L, D’Abrera V, McCann R, Peterson A, Armstrong P</td>
<td>Analysis of Hip and Knee Arthroplasty Surgical Site Infection Data in Western Australia: Null Effect of Stratification by Procedure Type</td>
<td>Infect Cont Hosp Epi</td>
<td>2012</td>
<td>33(3)</td>
<td>313-315</td>
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</tbody>
</table>
**Table 4 continued.** List of publications wherein data from HISWA have been used

<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Journal</th>
<th>Year</th>
<th>Vol(Is)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beckingham WD, Bull AL, Hall L,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Kennedy KJ, et al.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitchell BG, Collignon P,</td>
<td>A major reduction in hospital-onset <em>Staphylococcus aureus</em> bacteraemia in Australia - 12 years of progress: an observational study</td>
<td>Clin Infect Dis</td>
<td>2014</td>
<td>ciu508 online</td>
<td></td>
</tr>
<tr>
<td>McCann R, Wilkinson I, Wells A</td>
<td></td>
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</tr>
</tbody>
</table>

### 3.3 Simplicity

The system’s structure and ease of operation

#### 3.3.1 Data Management

The HISWA system application uses asp.net, an open source server-side web application framework created by Microsoft for web page development, as the "front end" or data entry website and an Oracle database for the "back end". Data are stored off-site from CDCD at the Health Information Network (HIN) since late 2007. HIN is the support and maintenance provider of information and communication technology (ICT) infrastructure and enterprise-wide applications for WA Health. HISWA is supported by Information Development & Management (IDM) under the PAQ Division and managed by HIN. Any modifications to HISWA are performed by IDM and implemented through HIN.

#### 3.3.2 Data Entry

For data entry fields which are completed by selecting a choice from a drop down menu, data are complete and consistent; whereas where data are entered in an open field textbox, data are often incomplete, inconsistent and error-prone. For example, laboratory numbers and patient identification numbers (UMRN) are often incomplete or incorrect. These errors can cause significant delay and compromised reliability of data analysis (HAIU Staff, personal comm., 15 April 2014).
3.3.3 **Denominator Data**

Within HISWA, there are four types of denominator data collected – bed-days, central line-days and haemodialysis patient-months, and the number of surgical procedures (hip and knee arthroplasty, C-sections) (Table 1b). Not all HCFs collect all denominator data types, as not all facilities perform the surgical procedures, and therefore, are not required to submit data regarding those procedures. Contributors reported in the survey that the retrieval of denominator data information from the TOPAS system or Business Management Unit is often difficult.

3.3.4 **Data Analysis**

The data extraction process from HISWA was designed so that no complex coding or programming was required. Data are analysed using both Microsoft Excel 2007 and Stata 12.1 (StataCorp, College Station, Texas). Data are aggregated and converted to rates, with each indicator using a denominator and population size that is appropriate to it (Appendix 4). Graphical representation is the most common display of the data in the quarterly and annual HISWA reports. Several types of graphs are used in the quarterly and annual reports, including bar graphs with 95% confidence interval (CI) lines, proportion bar graphs and pie graphs. Tables with large amounts of data regarding rates with 95% CIs for each indicator are also presented.

3.3.5 **Data Collection**

Data on HAI events are initially collected by the HCFs and investigated to determine if the event meets the definition of a HAI for specific indicators, and subsequently entered into HISWA. There is currently no standardised system in which these primary data are collected at the individual HCFs. Some HCFs currently use out-dated, unsupported electronic databases, such as the electronic Infection Control Assessment Technology (eICAT) MS access database, which does not interface with other WA Health patient information systems. Most continue to use manual data collection systems, which are error prone, labour intensive and time consuming. Regardless of the data collection system, the HCFs are required to manually re-enter the data into the HISWA database to allow for state-wide aggregation and analysis of data. If WA were to adopt AST, the interfacing with the current information management systems would need to be considered and may hamper the implementation process.
3.4 Flexibility

The ability to adapt to changing information needs or technological operating conditions with little additional time, personnel or allocated funds

A flexible surveillance system can adapt to changing information needs or operating conditions with little additional time, personnel or allocated funds. The HISWA system has the capacity to be flexible if small changes are required; however, when changes are required by HIN, due to time and cost limitations, the system is inflexible.

Data are categorised into six “indicator groups” in the HISWA database – specific organism bloodstream infections, CLABSIs, HD-BSIs, SSIs, occupational exposures and significant organisms (for MROs). Within those groups, indicator events appear on drop-down menus which the HAIU can alter from the front-end (website) of HISWA without requiring IT support. Small edits to the back-end (oracle database) of HISWA by HIN are required when new indicators are added in order to ensure completeness in the automatic extraction of data. An example of this was when the C-Section SSI indicator was added to the SSI indicator group in January 2011; following the addition of the indicator by the HAIU to HISWA, HCFs were able to report instantly (HAIU Staff, personal comm., 17 April 2014).

Changes to the case definitions and data collection fields require changes to the drop-down menus on the website, which is a simple procedure performed by HAIU, as it follows the same procedure as adding an indicator (as described above). However, the addition of a new indicator group requires considerable IT support due to changes required in the back-end of HISWA, which can be a drawn-out process due to competing priorities for HIN support.

New indicator groups have been added since the inception of HISWA, SABSIs in October 2007 and occupational exposures (OEs) in January 2008. Further indicator additions to HISWA have been through the add-on of drop-down menus and additional data fields. However, future requirements for more detailed information for CDI and VRE will require substantial changes to the back-end of HISWA, and therefore, are being postponed until the outcomes of a bid for the implementation of AST are known.
3.5 DATA QUALITY

The completeness and validity of the data recorded in the system

Data quality within the HISWA system is based upon three key factors: meeting the definition of a HAI for each indicator, internal validation of data by HCFs and validation of submitted data by the HAIU, and “zero-reporting” of data. Correct numerator and denominator data are imperative in the setting of public reporting and comparison of rates between HCFs.

3.5.1 ZERO-REPORTING

Data entered into the HISWA system must be finalised at the end of each month by each contributing HCF, verifying that the data entered is correct and complete for the facility. This ensures that any zeroes reported are in fact zeroes and not incomplete or lack of entered data – i.e. “zero-reporting”27. If a contributor does not finalise their data at the end of a month, the HAIU cannot accurately report aggregated state-wide data; whilst HISWA reports are still issued, there are caveats to explain any non-validated or missing data. Zero-reporting reduces the possibility of reporting incomplete or incorrect information, and thus increasing the data quality of HISWA.

3.5.2 INDICATOR DEFINITIONS

The definitions of HAIs used in HISWA are analogous with the ACHS definitions, and where indicators are not defined by ACHS, the definitions are based upon those of the CDC/National Healthcare Safety Network (NHSN). Definitions for the indicators reported to HISWA can be found in the HISWA Surveillance Manual, which can be accessed online on the HAIU webpage with the Public Health Division website of the Department of Health WA6,31. Consistent applications of standardised definitions are essential for high-quality data.

3.5.3 INTERNAL VALIDATION

Both SABSI and CDI indicators undergo formal internal validation by the HAIU each month. Data for positive results for SABSI and CDI, which are downloaded from the state pathology service (PathWest Laboratory Medicine), are received two weeks following the end of the current calendar month, e.g. October data are received in mid-November. Data are cross-checked with data entered into HISWA and any discordant or irregular results within the system (e.g. one site reporting more than usual) of any indicator are further investigated with the contributing HCF. Data from private hospitals (both mandatory and
voluntarily submitted) reported to HISWA are not formally validated, as access to private laboratory results is currently unavailable.

### 3.6 Acceptability

*The willingness of persons and organisations to participate in the system*

In WA, there are almost 10,000 beds across 113 HCFs, 87 public HCFs, 18 private HCFs and 8 haemodialysis-only facilities (Table 5). Of the 18 private HCFs that are not required to submit data to HISWA, 15 HCFs voluntarily submit data as they believe in the benefits of participating in state-wide HAI surveillance (HAIU staff, personal comm., Feb 2014).

**Table 5.** Breakdown of facility types and bed numbers reporting to HISWA. Data obtained from HISWA database, July 2014

<table>
<thead>
<tr>
<th>Facility type</th>
<th>Number of HCFs</th>
<th>Number of Beds</th>
<th>% Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public*</td>
<td>87</td>
<td>6,293</td>
<td></td>
</tr>
<tr>
<td>Reports</td>
<td>37</td>
<td>5,695</td>
<td>90.5%</td>
</tr>
<tr>
<td>Does not report†</td>
<td>50</td>
<td>598</td>
<td>9.5%</td>
</tr>
<tr>
<td>Private</td>
<td>18</td>
<td>2,895</td>
<td></td>
</tr>
<tr>
<td>Reports</td>
<td>15</td>
<td>2,797</td>
<td>96.6%</td>
</tr>
<tr>
<td>Does not report</td>
<td>3</td>
<td>98</td>
<td>3.4%</td>
</tr>
<tr>
<td>Haemodialysis only</td>
<td>8</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>113</strong></td>
<td><strong>9,188</strong></td>
<td><strong>92.4%</strong></td>
</tr>
</tbody>
</table>

*Public HCFs and private HCFs contracted to provide care to public patients †HCFs <50 beds

The fact that most private HCFs voluntarily participate in HISWA indicates the usefulness and acceptability of the system. This may be because of the dissemination of aggregated data back to the HCFs, the cost-saving benefits of an effective HAI surveillance system, and/or the ability to benchmark with other HCFs.

### 3.7 Sensitivity and Positive Predictive Value

*The proportion of cases of a disease detected by the system i.e. “completeness” (sensitivity) and the proportion of the events that actually have the event under surveillance (PPV)*

The sensitivity and positive predictive value (PPV) of a surveillance system can be considered on two levels – case definition and detection of outbreaks. A system that has a low sensitivity may still be useful in monitoring disease trends as long as the sensitivity remains reasonably constant over time. A low PPV will lead to unnecessary intervention and wasted time.
3.7.1 **CASE DEFINITION**

The sensitivity of the case definition refers to identifying all possible cases in the community; a very sensitive case definition may not be very specific and thereby increase the number of false positives. The PPV of the case definition is the proportion of true cases who meet the case definition – the higher the PPV of the case definition, the better. The PPV of case definitions is affected by the sensitivity and specificity and prevalence of the condition in the community – a low PPV indicates that either the case definition is not adequate or is not being applied appropriately.

As an example of compliance with reporting cases that meet the case definition, Table 6 shows the number of *C. difficile* events reported, added and/or deleted during each 6-month period from 2011 to 2013. Overall, 91% of *C. difficile* events reported to HISWA were correctly reported, with an average of 9% of CDI needing to be adjusted over the 36-month period showing a high level of concordance with the case definition for CDI.

**Table 6. Validation data of *C. difficile*, 2011 – 2013. Data obtained from HISWA database, July 2014**

<table>
<thead>
<tr>
<th></th>
<th>Added</th>
<th>Deleted</th>
<th>Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2011</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan – Jun</td>
<td>12 (4%)</td>
<td>9 (3%)</td>
<td>250 (93%)</td>
</tr>
<tr>
<td>Jul – Dec</td>
<td>34 (7%)</td>
<td>27 (6%)</td>
<td>393 (87%)</td>
</tr>
<tr>
<td><strong>2012</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan – Jun</td>
<td>17 (3%)</td>
<td>24 (5%)</td>
<td>481 (92%)</td>
</tr>
<tr>
<td>Jul – Dec</td>
<td>19 (4%)</td>
<td>25 (5%)</td>
<td>456 (91%)</td>
</tr>
<tr>
<td><strong>2013</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan – Jun</td>
<td>34 (8%)</td>
<td>12 (3%)</td>
<td>396 (89%)</td>
</tr>
<tr>
<td>Jul – Dec</td>
<td>6 (3%)</td>
<td>1 (1%)</td>
<td>186 (96%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>122 (5%)</strong></td>
<td><strong>98 (4%)</strong></td>
<td><strong>2162 (91%)</strong></td>
</tr>
</tbody>
</table>

The high proportion of adjusted events were mostly due to the repeat reporting of CDI in patients within an 8-week period, which according to the HISWA definition is the same CDI event rather than a separate event. If a patient were to present at different HCFs, this patient would be reported more than once in HISWA as there is currently no patient tracking available for the HCFs to check previous reports for CDI in across both the public and private laboratory systems. HAIU performs internal validation of CDI events to remove these duplicate reports, thereby increasing the sensitivity and PPV of CDI surveillance (Appendix 1).

From the total number of CDI reports from 2011 – 2013, the sensitivity of HISWA to detect CDI can be estimated at 95%, and the PPV at 96%. This indicates that the system is not detecting many false positives and is capturing the majority of cases that occur.
3.7.2 Outbreak Detection

It should be noted that the HISWA system was not designed to be used for the timely detection of outbreaks within individual HCFs by the HAIU, as the analysis and reporting of HISWA is tailored towards observing longer trends (HAIU Staff, personal comm., April 2014). HAIU reviews the overall trends state-wide; governance and accountability for HAIs lies with the individual HCF, and it is the responsibility of the IPCPs to detect outbreaks in a timely manner.

3.8 Representativeness

The ability to accurately describe the occurrence of a health related event over time and its distribution in the population by place and person\(^9\)

Approximately 92.5% (n = 8492) of all beds in WA are within HCFs that report HAI events to HISWA. The other 7.5% (n = 696) of beds are within 52 HCFs that do not report to HISWA; 50 facilities are small country health services with the majority (92%) having less than 25 beds, whilst two facilities are smaller private hospitals (Table 5). The smaller HCFs do not report to HISWA as they have low volumes of acute patient activity, or capacity (e.g. doctors, technology) to provide acute inpatient services to contemporary standards and limited personnel to meet HISWA surveillance requirements. HCFs that are smaller than 25 beds are also exempt from national reporting (HAIU staff, personal comm., Feb 2014).

That 92.5% of beds are within HCFs that report to HISWA indicates that the system is highly representative of the HCFs throughout the state, capturing the majority of HAI events and improving IPC practices within the majority of WA HCFs. Data are not representative of the whole population at risk of HAI. The HAIs that are currently collected in HISWA are only a small proportion of all infections that are healthcare-associated.

Whilst the proportion of beds within HCFs throughout WA covered by HISWA is high, there is the potential that a HAI is not detected because it occurred post-discharge and the patient is not re-admitted to hospital for treatment of the infection. Post-discharge surveillance (PDS) is resource intensive for IPCPs and there is currently no standardised PDS methodology. HISWA data show that there is a high detection rate for HAIs on readmission to hospital for infection, e.g. SSI following hip or knee arthroplasty. In a study which performed PDS of C-section SSIs in the UK, there were complications which met the definition of a HAI SSI in 8.9% of cases\(^{33}\). Follow-up was performed during the routine
appointments with the community midwife. This was made possible due to the combined administration of healthcare throughout the UK; the current structure of healthcare in Australia means this may not be entirely feasible.

3.9 Timeliness

Reflects the speed between steps in a system

Two main components affect the timeliness of the HISWA system – the data collection and entry and the publication of reports.

3.9.1 Data Collection and Entry

Data are submitted to HISWA by contributors at a time within the reporting month that is suitable to the HCF, either on an ad-hoc basis, weekly, fortnightly and/or monthly. HISWA business rules require that data must be finalised by the HCF at the conclusion of each month (Figure 4).

![Figure 4. Timeline of data collection and entry to HISWA](image)

In order to identify whether a case is a HAI, investigation and assessment of the case according to the definitions are required. From the online survey it was found that the average time spent investigating each case was 30-60 minutes. This approximates to more than 1,469 hours spent investigating HAI events, and 1,382 hours spent investigating occupational exposures throughout the 2012-2013 financial years (2,851 events). However, this is a gross underestimation, as these hours are calculated on the number of events reported to HISWA and do not reflect the time spent investigating cases that do not fulfil the definition and subsequently are not reported as HAI events.
Furthermore, the flow of data is hampered by the need to manually enter data onto the HISWA database. Most contributors to HISWA reported that they pool their cases and enter the data at the end of the month. Denominator data must also be collected and entered; however, most contributors reported that the entering of denominator data took less than one hour per month to perform.

3.9.2 Reports

Reports are issued by the HAIU every month, quarter and year (Figure 1) and are sent out to various organisations and committees (Appendix 4). In the online survey, contributors reported that they or their facility made use of both the data collected and the reports generated by HAIU by communicating back to the clinical workforce via a number of mechanisms and they are used for education and to improve IPC performance. The executives who were questioned about the use of reports in their HCFs mentioned that they are sent to their peak quality and safety governance committees. They are used for internal benchmarking, to identify increased rates of HAI events at their HCF and external benchmarking with other HCFs, aggregated WA rates, national and international rates.

Analysis and interpretation of results of HISWA data takes time and experience. The reports are produced by the three staff members of the HAIU. Feedback from the executives who responded to the email survey indicated that the quarterly reports could be timelier in being released, as the following quarter is already over before any actions are able to be taken. However, quarterly data cannot begin to be collated and analysed until at least a month after the close of the quarter due to surveillance definitions that require a minimum follow-up period of 30 days following the procedure. Whilst the comments of the executives are valid, the HAI definitions and the current infrastructure of HISWA do not allow for real time reporting.

3.10 Stability

_The system’s reliability and availability^9_

The database entry for HISWA is web-based and available to those registered with a valid user name and password. Planned outages occur in order to update servers or repair hardware, and usually occur after business hours to reduce disruption to HISWA users (R McCann, personal comm., March 2014).

Some HCFs in WA currently utilise eICAT to record and report IPC data, however, this program does not allow for automatic input from other WA Health systems, such as TOPAS and ULTRA. The eICAT system developers have ceased to provide support, so there will be
no further upgrades or new features available. WA Health proposes to introduce AST in each public sector HCF, which would replace this outdated software.

3.11 Resources for System Operation

With limited public health funding for detection and response, assessment of resources devoted to surveillance is critical.\(^9\) Prevention can cost less than treating HAIs\(^11\). A robust and updated surveillance system can reduce the incidence of HAIs, whilst out-dated and poorly supported systems take the IPCP away from IPC activities such as education, implementing evidence-based strategies to prevent HAIs, and auditing compliance.

3.11.1 Human Resources

Questions on time spent on data collection and reporting for the HISWA system were asked in the online survey in order to estimate the crude costs associated with gathering information.

The pay rates of HISWA contributors can be used to estimate hourly costing: Registered Nurse at RN Level 2.4, the lowest level IPCP is paid $44.18 p/h whilst the senior IPCPs are paid up to $64.09 p/h (SRNs level 7). The majority of IPCPs are RN level 2.4, however at each tertiary hospital there are senior IPCPs who oversee the IPC teams, most of which are paid as either SRN level 4 or 7. As discussed earlier, the majority of contributors (n = 18) reported that they spend an average of 30-60 minutes collecting data on each event; the estimated time to collect and enter data for HISWA within the 2012-13 reporting period is estimated at 2,851 hours. Table 7 details the number of events and the associated costs reporting to HISWA in 2012-2013 for each indicator collected.

This is most likely a lower estimate of the costs, as some IPCP may be paid at higher rates. The time allocation may be significantly under-reported as they are not likely to reflect the time spent investigating cases that do not meet the definition of a HAI\(^35\) and does not include investigations of HAIs not reported to HISWA. This estimate represents only the cost of the time spent investigating the case, this does not include the cost of the screening, laboratory investigations or treatment of the HAI.
Table 7. Estimated labour costs for time spent investigating healthcare associated infection events for reporting to HISWA by infection prevention and control professionals at Registered Nurse level 2.4 (ANF pay rates, 2014) in West Australian healthcare facilities

<table>
<thead>
<tr>
<th>Indicator</th>
<th>No. events</th>
<th>RN Level 2.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>42</td>
<td>$1,856</td>
</tr>
<tr>
<td>Knee</td>
<td>40</td>
<td>$1,767</td>
</tr>
<tr>
<td>C-section</td>
<td>57</td>
<td>$2,518</td>
</tr>
<tr>
<td>HD-BSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>3</td>
<td>$133</td>
</tr>
<tr>
<td>Cuffed catheter</td>
<td>39</td>
<td>$1,723</td>
</tr>
<tr>
<td>MRSA</td>
<td>176</td>
<td>$7,776</td>
</tr>
<tr>
<td>CLABSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haematology</td>
<td>18</td>
<td>$795</td>
</tr>
<tr>
<td>ICU</td>
<td>9</td>
<td>$398</td>
</tr>
<tr>
<td>Oncology</td>
<td>9</td>
<td>$398</td>
</tr>
<tr>
<td>SABSI</td>
<td>161</td>
<td>$7,113</td>
</tr>
<tr>
<td>CDI</td>
<td>912</td>
<td>$40,292</td>
</tr>
<tr>
<td>Occupational Exposures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental</td>
<td>1040</td>
<td>$45,947</td>
</tr>
<tr>
<td>Non parental</td>
<td>342</td>
<td>$15,109</td>
</tr>
<tr>
<td>TOTAL COST FOR 2013</td>
<td>2,851</td>
<td>$190,858</td>
</tr>
</tbody>
</table>

The costs for HAI surveillance were calculated by averaging the total number of events reported to HISWA in 2012-13 and multiplying it by the hourly rate of an ICP paid at RN level 2.4, assuming that each event takes 60 minutes to investigate. Many survey respondents commented that the resource-intensive nature of the HISWA system means that the time spent collecting data left little time to implement any IPC changes.

3.11.2 Information Systems

To determine if an infection meets surveillance definitions, various sources of data are required to gather case information, and the ease of accessing this information can vary greatly among hospitals. In the online survey, contributors were asked to list all the information sources their HCF uses to investigate HAI (Table 8).
Table 8. Information sources currently in use in West Australian healthcare facilities for infection prevention and control purposes as of July 2013

<table>
<thead>
<tr>
<th>Database/Source</th>
<th>% of HCFs</th>
<th>Database/Source</th>
<th>% of HCFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMS</td>
<td>43.2</td>
<td>eICAT</td>
<td>21.6</td>
</tr>
<tr>
<td>ULTRA</td>
<td>37.8</td>
<td>WebPAS</td>
<td>18.9</td>
</tr>
<tr>
<td>ICM</td>
<td>35.1</td>
<td>Pathology/lab results</td>
<td>18.9</td>
</tr>
<tr>
<td>TOPAS</td>
<td>32.4</td>
<td>HCare</td>
<td>16.2</td>
</tr>
<tr>
<td>Discharge summaries</td>
<td>29.7</td>
<td>Patient notes/records</td>
<td>16.2</td>
</tr>
<tr>
<td>Facility Intranet</td>
<td>24.3</td>
<td>ACCESS database</td>
<td>5.4</td>
</tr>
</tbody>
</table>

4. DISCUSSION

“The purpose of evaluating public health surveillance systems is to ensure that problems of public health importance are being monitored efficiently and effectively”9. Most would agree that the surveillance of HAIs is of public health importance, and that HISWA is an effective monitoring system. However, there are ways in which the current HISWA system could be more efficient.

4.1 PURPOSE AND OBJECTIVES

*Purpose 1: Ensure all WA hospitals utilise standardised definitions and methodology*

HISWA provides a surveillance manual that includes surveillance definitions and methodology for each indicator. Standardised tools for collection of data have been developed, which are available on the HISWA website along with the surveillance manual6,31.

*Purpose 2: Ensure the validity of data through formal and informal validation exercises*

Since the inception of HISWA in 2005, there have been two formal validation exercises performed for SABSI and SSI data6,36,37. SABSI events reported to HISWA were evaluated in 2008 by comparing all SABSIs diagnosed in public hospitals and found to be an HAI to those reported in the HISWA database. The system had a sensitivity of 77% (119/155) and specificity of 99% (258/259)36. However, it is important to note that these findings cannot be extrapolated, as the study was confined to only those SABSI events which occurred in public hospitals. It should also be noted that at the time of this study, not all haemodialysis units (including private satellite units) were reporting SABSI infections to HISWA. However, in January 2010 an Operational Circular (IC 0042/09: *Healthcare Associated Infection Surveillance – Mandatory Reporting*) mandated the reporting of all haemodialysis access-associated BSIs, including SABSIs. A formal validation study of SSI
events following hip and knee arthroplasty was conducted in November 2008, finding a sensitivity of 83% and specificity of 99%, with PPV and NPV at 94% and 97%, respectively.\textsuperscript{37,38}

As a result of those findings, the HAIU now performs on-going validation for SABSIs and CDI events at public hospitals (i.e. those infections that are diagnosed by PathWest laboratories), so that if an event is missed, the HAIU can add it to the data and subsequently follow up with the corresponding HCF to discuss why this may have been missed in their surveillance. This increases the sensitivity of the system in capturing SABSI events, with 87 of the 113 HCFs reporting to HISWA being serviced by PathWest laboratories. MRSA notifications are established to be true MRSA cases by confirming with the ACCESS Typing and Research Laboratory database.

For both sensitivity and PPV to be calculated for the entire HISWA system, a large-scale evaluation of these two attributes would have to be performed. This would be expensive and labour intensive and this knowledge may not be beneficial overall.

\textit{Purpose 3: Provide support to surveillance personnel contributing data to HISWA}

The HAIU invests considerable time and effort educating the contributors of HISWA on the surveillance requirements and definitions outlined in the HISWA Surveillance Manual and updates through formal education sessions, quarterly HISWA forums, and regular one-on-one interactions with IPCPs. HAI events that are disputed as a result of HAIU internal validation are discussed with the HCF IPC team.

\textit{Purpose 4: Reflect the importance of HAIs within the WA Clinical Governance Framework}

Pillar three of the \textit{WA Health Clinical Governance Framework} concentrates on minimising clinical risk and improving overall clinical safety. The three aspects of clinical management as stated in the framework are integral to the structure of HISWA and are:

i. Incident and adverse event reporting, monitoring and trend analysis

ii. Sentinel event reporting, monitoring and clinical investigation

iii. Risk profile analysis

\textit{Purpose 5: Provide high quality comparative data}

HISWA data are analysed using risk-adjusted aggregated HAI rates where possible to better reflect differences in clinical case-mix between participating hospitals. The ability for benchmarking of HAI rates throughout WA was commented on as the major strength of the HISWA system in both surveys of contributors and executives.
Aggregation of data allows analysis of a larger dataset with increased statistical value, i.e. a pooled mean rate along with the cumulative incidence of infections as a proportion of the total number of patients at risk. HISWA monitors state-wide trends and may identify systemic problems, e.g. IVD-related SABSI, and informs on the need for comprehensive actions to be taken across all HCFs. HCFs can benchmark against the state aggregate rate (pooled mean rate), and the state aggregate rate can be used to benchmark with other jurisdiction rates, e.g. MRSA policies in WA are reflected in a low MRSA HAI rate compared to other jurisdictional rates.

At present, HISWA data are presented as notifications and aggregated rates. Whilst this indicates changes from year to year, or facility to facility, it does not present the whole picture. Differences in notifications and rates could be due to “common cause variation” i.e. natural differences between facilities, or “special cause variation”, i.e. unusual or serious problems.

Currently, the CDC/NHSN use risk-adjusted standardised infection ratios (SIRs) to compare HAI rates in a facility/state with baseline rates in the general US population. The SIR is calculated in a similar way to standardised mortality ratios; a ratio greater than one indicates the rate has increased, a ratio equal to one indicates the rate has remained constant, and a ratio less than one indicates the rate has decreased. No jurisdiction in Australia currently analyses and/or presents their data in this manner, but this could be useful in the future (HAIU Staff, personal comm., 01 May 2014). Control charts can be useful for analysing the data at a facility or jurisdictional level. Data are presented on a scatter graph, with three lines - the median across all facilities and the upper and lower control limits. Data points which lie outside of the control limit lines show “special cause variation” and require investigation. HISWA could easily change to publishing control charts for aggregated rates, which would allow for greater comparison between HCFs and/or other jurisdictions. Whilst education in the reading and interpretation of new graphs would be required, control charts present data in a way that communicates with ease whilst incorporating statistical thinking.

Purpose 6: Help inform system-level priority

HISWA uses surveillance data presented at HICWA to identify issues and problematic trends in order to inform and prioritise change required to decrease HAIs in WA HCFs.

Purpose 7: Evaluate prevention programs in WA

The HAIU acknowledges that more can be done in bringing together HISWA data and IPC strategies/programs (HAIU Staff, personal comm., 21 May 2014). Examples of previous
evaluations include the monitoring of data post-introduction of prevention bundles at specific HCFs, surveys conducted by HAI, and participation within the West Australian Point Prevalence Survey (WAPPS) to determine issues surrounding intravenous line related phlebitis and BSIs.

**Objective 1: Identify trends and engage clinicians to review clinical care and processes to minimise infection risks**

There are multiple ways in which the HAIU utilise trends detected in HISWA to engage IPCPs, clinicians and HCF executives to review IPC processes. The quarterly HISWA Forum allows overarching issues to be discussed; whilst the WAMRO EAG and HICWA meetings discuss specific issues surrounding IPC. A recent example was an extraordinary meeting of the WAMRO EAG to discuss the issues surrounding on-going transmission of VRE within a metropolitan HCF.

**Objective 2: Ensure activities are aligned, where possible, with Australian and international surveillance programs to allow for relevant external benchmarking**

Depending on the surveillance indicator, HISWA uses HAI surveillance definitions utilised by the CDC/NHSN, the ACHS and the ACSQHC definitions. This signifies that HISWA data can be compared to jurisdictions that utilise the same HAI definitions, allowing for external benchmarking. The indicators collected within HISWA are the same as those collected in most other jurisdictions in Australia, excepting CABGs and surgical antibiotic prophylaxis1. When compared to which HAI events are collected internationally, indicators cannot be compared directly without first giving consideration to the variations in professional culture or clinical practice41.

### 4.2 LIMITATIONS

The effectiveness of HISWA could be improved by reducing the time spent on data collection and entry by the introduction of AST throughout WA HCFs. The time taken in investigating each potential HAI is a heavy burden for the IPCP. Automatic harvesting of data by AST would decrease the time spent on fact-finding and data entry, as well as reduce the risk of human error17. Data quality would be improved through integrated checks written into the AST program. Whilst the cost of purchasing or developing AST is an obvious issue, the cost saved in staff time spent on data entry would be high, potentially increasing patient outcomes as the focus of IPC departments could be shifted from data collection, entry and analysis to putting into place practical infection control measures28,42,43.
The indicators collected currently for HISWA cover a range of serious infections; however, as the system only collects data for 11 HAI events and occupational exposures, HISWA may miss important indicators that represent possible gaps in infection prevention and control and reflect the true burden of HAI events within the HCF. However, it is not necessary that the system capture all HAI events that occur in a HCF, as the purpose of HAI surveillance is to give indication of the quality of care and success of IPC interventions. HAI surveillance is best targeted at indicators that are of large enough volume for meaningful statistical analysis and the HAIs that are amenable to intervention.

As smaller HCFs are not currently required to report to HISWA, the representativeness of HAI rates across HCF facilities in WA is limited to larger HCFs. Whilst smaller HCFs have lower volumes of acute patient activity, patients are still at risk of developing a HAI. Any understanding of HAIs derived from HISWA data or IPC intervention developed is thereby limited to the population within larger HCFs.

In review of the final report, the potential for measurement bias for the questions regarding timing due to overlapping time categories was highlighted. For example, Question 5 asks “On average, how long (minutes) does it take for you to find and gather information on a single event?”, with the possible answers being less than 10 minutes, 10 to 30 minutes, 30 to 60 minutes, greater than 1 hour and not applicable. The overlapping time for 30 minutes in two categories may have led to people nominating either category. It is unlikely that this would have had a major error, but does represent a problem with questionnaire design, which should have been identified prior to administration of the survey. Unfortunately, these errors were discovered after the conclusion of the study, and therefore the possibility of resurveying the stakeholders was impossible. The data presented in this chapter has not been manipulated to account for this potential bias.
5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

Overall the HISWA system is well accepted by HCFs and IPCP across the state, both for those who are required to report and those who voluntarily report. However, the resources required in identifying HAI cases and information for HISWA are at capacity, and as such, limit the possibilities of adding other indicators, performing more analysis and improving report timeliness is currently unfeasible.

5.2 RECOMMENDATIONS

These recommendations were developed in consultation with the members of the HAIU and Dr Paul Armstrong (Head of CDCD) in response to the results from the contributors’ survey and the evaluation of HISWA. The feasibility of implementing these recommendations was beyond the scope of this evaluation.

Recommendation 1: That AST is introduced for automated harvesting and reporting of data

The standardisation of collection methods through a roll-out of AST, allowing for the automated information harvesting across WA HCFs would reduce data errors and time spent on data searching. The HAIU currently has plans to introduce such a program and is awaiting confirmation from Treasury.

Recommendation 2: That there is the addition of new indicators

Currently, HISWA collects data for 11 indicators, some of which are also collected in other jurisdictions/countries. In both the online survey of contributors and email survey of executives, the following infection events were suggested for indicators that could be collected in the future through the HISWA system:

- SSIs from cardiothoracic procedures, e.g. CABGs
- SSIs from colorectal surgery
- VAP surveillance
- CREs, ESBL organisms and other emerging MROs
- Annual invasive device audits
- Compliance with bundle processes/checklist
- Surgical antibiotic prophylaxis

Whilst it may not be necessary to collect data on each HAI event that occurs in a HCF, by increasing the scope of knowledge of HAI events in HCFs, IPC teams will be better
informed to work with nurses, clinicians and executives to reduce the rates of infection in their facility.

**Recommendation 3: That the HISWA “Terms of Reference” are updated**

The current “Terms of Reference” for HISWA is the original document from June 2005 and needs to be updated, especially if the purchase and integration of AST occurs.

**Recommendation 4: That there is a change of data analysis and reporting graphs to better allow for comparisons to other jurisdictions**

Change of graphs to control charts and scatter plots would allow for simple visual comparison of facilities and jurisdictional rates with baseline estimates.

**Recommendation 5: Those HCFs of beds less than 25 to report to a regional key to report on their behalf**

As stated earlier, smaller HCFs do not currently report to HISWA as they have very low volumes of acute patient activity and limited personnel to conduct surveillance activities. Also, HCFs that are smaller than 25 beds are exempt from national reporting (HAIU Staff, Personal Comm., Feb 2014). However, it is important to know that the quality of care delivered in these smaller HCFs meets the standards required of WA HCFs. Small HCFs are currently registered to submit data to HISWA, therefore increased coverage of HAI surveillance is possible. Small HCFs could either collate HAI event data and forward to a key regional HCF to submit the data on their behalf, or contribute independently.

**Recommendation 7: That there is increased capacity of the HAIU for analysing, reporting, timeliness and use of data in publications by increasing staff and technology**

The HAIU at the time of this report has three full-time staff who work on state-wide policy development, analysing and reporting and validating HISWA data, as well as training IPCPs in surveillance, as well as secretariat work for HICWA, WAMRO and the Micro-Alert Governance Group that oversees, the WA Micro-alert system and CA-MRSA surveillance. Appendix 4 lists the 13 reports published regularly by the HAIU for HISWA. HISWA is an effective system, and whilst the HAIU constantly publishes reports, the HAIU does not regularly publish its findings in the form of journal articles. The data collected in HISWA should be used to publish more in order to achieve a greater understanding of infection prevention and control strategies along with the epidemiology of HAIs within WA.
The addition of another Project Officer to the HAIU or the creation of student projects for Masters Students using pre-existing data could increase the capabilities of the HAIU to enhance analysis of the data, introduce new reporting methods such as control charts, and publish journal articles and scientific reports from the data collected in HISWA.

6. REFERENCES


7. Department of Health WA. In: Od 0487/14: Data stewardship and custodianship policy. 2014


7. APPENDICIES

APPENDIX 1 – INTERNAL VALIDATION METHODS

The following are the internal validation procedures of the indicators collected in HISWA as per the HISWA Surveillance Manual.

Surgical Site Infections
A surgical site infection (SSI) can be classified as either a superficial incisional, deep incisional or an organ / space infection. HISWA data combines deep incisional and organ / space infections to allow for more meaningful statistical analysis and align with published reports from other jurisdictions.

*Internal validation of SSIs*
Each infection that appears in HISWA is reviewed to determine if they are congruent with the definition of a SSI – meeting the set criteria or are deemed appropriate. Where the infections do not meet the definition, the site is contacted by the HAIU to discuss the case and is subsequently deleted.

MRSA infection
An MRSA infection is when MRSA is isolated from either:

a) a sterile site

b) a non-sterile site and MRSA-specific antibiotic therapy is administered by a clinician

All MRSA strains (community or healthcare) are included in the surveillance. Note: Patients that are given empirical treatment for a suspected MRSA infection, even if known MRSA carriers, should not be included in the surveillance.

*Internal validation of MRSA infections*
Each case is determined if actual MRSA case by cross-checking with the ACCESS database. Typing and strain is identified and added to the database. The type of infection is reviewed to ensure that the infection meets the criterion of an infection and that it is being treated with MRSA drugs – followed up where necessary.

Hospital-identified CDI case
A hospital-identified CDI case is CDI identified in a patient attending any area of a hospital i.e. admitted patients and those attending emergency and outpatient departments. A hospital-identified CDI case reflects the burden of CDI on a hospital and describes
healthcare-associated infections, community-associated infections, as well as CDI of indeterminate or unknown origin

*Internal validation of CDIs*

The data of all cases of CDI detected by PathWest Laboratory Medicine is downloaded by HAIU. All non-HISWA cases and repeats are discarded, with the remaining cases looked at

*VRE sterile site infection*

A VRE sterile site infection is when VRE is isolated from a specimen obtained from a sterile site. Do not report VRE isolated from a specimen obtained from a non-sterile site e.g. wound, urine, and sputum. Note: Patients that are given empirical treatment for a suspected VRE infection, even if known VRE carriers, should not be included in the surveillance.

*Internal validation of VREs*

At the time of this report, ad-hoc validation was being performed by the HAIU

*Staphylococcus aureus bloodstream infection (SABSI)*

A patient episode of SABSI is defined as a positive blood culture for *S. aureus*. Only the first isolate per patient within a 14-day period is counted. If the same patient has a further positive blood culture reported greater than 14 days after the last positive blood culture, then an additional episode is recorded (14-day rule). The 14-day rule is to be applied to SABSI that occur in haemodialysis patients (not the 21 days specified for haemodialysis access-associated bloodstream infection surveillance).

*Internal validation of SABSI*

All SABSI cases are validated by the HAIU. This involves an automatic download from PathWest (the state laboratory service) of all SABSI once a month, from which each patient is cross-checked, using ICM, program to determine if they meet the criteria for a HA-BSI. This check is performed independently of what is entered in the HISWA database. Once the cross-check is complete, it is then compared to what is entered into HISWA and any discordant cases are formally discussed with the healthcare providers. The majority of the time cases are added to the list, not often are they removed.

*Central line-associated bloodstream infection (CLABSI)*

First, the criteria for classification as a BSI event must be met (refer to Appendix 5). A CLABSI is a laboratory confirmed BSI in a patient where a central line has been in situ within the 48-hour period before the detection of the BSI, and is not related to an infection at another body site i.e. there is no other identifiable focus of infection.
**Internal validation of CLABSI**
At the time of this report, no internal validations of CLABSI events were being undertaken.

**HD vascular access**
Refers to any intravascular access utilised for the purpose for haemodialysis e.g. cuffed or non-cuffed central venous catheters, arterio-venous grafts or fistulae (refer to section 4).

**Internal validation of HD-BSIs**
As the reporting of these events is few, follow-up on individual events is performed by the HAIU to ensure that this is a true event.

**Occupational exposure**
An occupational exposure is an incident that occurs during the course of a person’s paid or unpaid employment where there is a risk of acquiring a blood borne virus (BBV) following exposure to another person's blood, tissue, or other body fluids that are potentially infected with a BBV. Occupational exposures are classified as parenteral or non-parenteral.

**Internal validation**
Any HISWA event group as “Parental – other” is questioned by the HAIU Project Officer to determine what this is and whether it meets the criteria. No other validation is performed for OE’s as it is thought that this would be validated on-site.
APPENDIX 3 – SUMMARY OF HISWA SURVEY RESPONSES

In October 2013, all end-users of the Healthcare Infection Surveillance Western Australia (HISWA) system, including infection control practitioners (ICPs), nurses and other end-users, were invited to complete an online survey which asked for feedback on several key issues, such as

- timeliness,
- information sources,
- simplicity and understanding,
- the reports generated by Healthcare Associated Infection Unit (HAIU) and
- opinion on the strengths and weakness of the system

This report gives the findings from the survey, broken down into the relevant sections, with each question supplied as per the survey. All questions within the survey had comment boxes so that end-users could explain the reason behind their answer if they felt necessary. Where appropriate these comments have been added to this report.

Respondents

A total of 37 ICPs completed the survey, 26 from metropolitan locations, and 11 from rural locations, with an overall response rate of 47.31% across Western Australia (Table 1). There was no difference in the response rate between metropolitan and rural healthcare services ($p = 0.46$) or in the representation of respondents from Public and Private healthcare providers ($p = 0.81$) [using Fischer’s Exact] (Table 2).

Table 1. Location of survey respondents

<table>
<thead>
<tr>
<th>Region</th>
<th>Total</th>
<th>% of respondents</th>
<th>% of WA facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan - Non-Tertiary Hospital</td>
<td>7 (18.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metropolitan - Tertiary Hospital</td>
<td>9 (24.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WACHS - Integrated District Hospital</td>
<td>5 (13.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WACHS - Regional Resource Centre</td>
<td>5 (13.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Hospital - with Public patients</td>
<td>1 (2.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Hospital - without Public patients</td>
<td>6 (16.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haemodialysis Unit - Private</td>
<td>2 (5.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2 (5.4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Type of facilities respondents represented in HISWA survey
**Timeliness**

Questions about how long is spent on collecting and entering in data were asked to determine if the current HISWA system impacted upon data quality and time spent performing data collection and entry rather than performing infection prevention and control activities.

**Q5. On average, how long (minutes) does it take for you to find and gather information on a single event?**

The majority of respondents claim to take 30-60 minutes gathering information on a single event (Table 3); however, it was stated in several comments that the total time spent is dependent upon type of infection, and the availability of the patient notes/records.

**Table 3. Question 5 - average time spent gathering information for a single event**

<table>
<thead>
<tr>
<th>Average time taken</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10 minutes</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>10 - 30 minutes</td>
<td>10 (27.0)</td>
</tr>
<tr>
<td>30 - 60 minutes</td>
<td>18 (48.7)</td>
</tr>
<tr>
<td>&gt; 1 hour</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>Did not answer</td>
<td>1 (2.7)</td>
</tr>
</tbody>
</table>

**Q6. How often is information at your facility entered into HISWA?**

Most respondents state that their facility enters the data at the end of the month (Table 4).

**Table 4. Question 6 - when information is entered into HISWA**

<table>
<thead>
<tr>
<th>When information is entered to HISWA</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the end of each month</td>
<td>21 (56.8)</td>
</tr>
<tr>
<td>At the end of each week</td>
<td>1 (2.7)</td>
</tr>
<tr>
<td>Case-by-case basis</td>
<td>12 (32.4)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>Did not answer</td>
<td>1 (2.7)</td>
</tr>
</tbody>
</table>

**Q7. On average, how long does it take for you to complete data entry for a case? (Responses from those 12 who entered “on a case-by-case basis” in previous question)**

Of the 12 that responded that they entered their information to HISWA on a case by case basis, 10 responded that they spend less than 10 mins entering in data for each case.

**Q8. On average, how many hours per week do you spend entering data for HISWA?**

There was only 1 respondent who enters data the end of the week, and they claim to spend 1-2 hours per week on data entry.
Q9. On average, how many hours per month do you spend entering data for HISWA?

All respondents were asked this question no matter their frequency of data entry. The majority of respondents spend less than 2 hours (Table 5). Those who stated it was not applicable said that their data was entered in by a data manager (who will be interviewed).

**Table 5. Question 9 - the average time spent data to HISWA each month**

<table>
<thead>
<tr>
<th>Time spent entering data per month</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 hour</td>
<td>13 (35.2)</td>
</tr>
<tr>
<td>1-2 hours</td>
<td>14 (37.8)</td>
</tr>
<tr>
<td>2-3 hours</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>&gt; 3 hours</td>
<td>3 (8.1)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>Did not answer</td>
<td>1 (2.7)</td>
</tr>
</tbody>
</table>

Q10. On average, how many hours per month do you spend collecting and reporting denominator data? e.g. bed-days, patient-months

Table 6 shows that the majority of respondents spend less than one hour a month collecting and reporting denominator data.

**Table 6. Question 10 - the average time spent collecting and reporting denominator data for HISWA**

<table>
<thead>
<tr>
<th>Hours per month denominator data</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 hour</td>
<td>21 (56.8)</td>
</tr>
<tr>
<td>1-2 hours</td>
<td>5 (13.5)</td>
</tr>
<tr>
<td>2-3 hours</td>
<td>5 (13.5)</td>
</tr>
<tr>
<td>&gt; 3 hours</td>
<td>5 (13.6)</td>
</tr>
<tr>
<td>Did not answer</td>
<td>1 (2.7)</td>
</tr>
</tbody>
</table>

**Information Sources**

This section of questions asked the end-user about which computer programs they used in their facility for infection prevention and control activities. The answers to these questions will be useful for the team planning the new computer program in knowing what information sources need to be interfaced with for its implementation across the state.

Q11. What computer databases/systems do you use at your facility for all your infection control activities (i.e. not just for HISWA)? (Multiple items can be selected)

Question 11 asked about all the databases/systems and information sources end-users of HISWA employ to collect data for their infection prevention and control activities. These responses answered two questions, 1) which computer systems and information sources are being used (Table 7a), and 2) how many information sources are being used for infection prevention and control purposes at each facility (Table 7b).
Table 7a. Question 11 – which computer databases/systems and information sources end-users of HISWA utilise to collect data for infection prevention and control activities.

<table>
<thead>
<tr>
<th>Source</th>
<th>Count</th>
<th>% of all HCFs</th>
<th>Source</th>
<th>Count</th>
<th>% of all HCFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMS</td>
<td>16</td>
<td>43.2</td>
<td>eICAT</td>
<td>8</td>
<td>21.6</td>
</tr>
<tr>
<td>ULTRA</td>
<td>14</td>
<td>37.8</td>
<td>WebPAS</td>
<td>7</td>
<td>18.9</td>
</tr>
<tr>
<td>ICM</td>
<td>13</td>
<td>35.1</td>
<td>Path/lab results</td>
<td>7</td>
<td>18.9</td>
</tr>
<tr>
<td>TOPAS</td>
<td>12</td>
<td>32.4</td>
<td>HCare</td>
<td>6</td>
<td>16.2</td>
</tr>
<tr>
<td>Discharge summaries</td>
<td>11</td>
<td>29.7</td>
<td>Patient notes/ records</td>
<td>6</td>
<td>16.2</td>
</tr>
<tr>
<td>Facility Intranet</td>
<td>9</td>
<td>24.3</td>
<td>Access database</td>
<td>2</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Table 7b. Question 11 - Number of information sources used at facility

<table>
<thead>
<tr>
<th>Number of sources used at HCF</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>8 (21.6)</td>
</tr>
<tr>
<td>3-4</td>
<td>18 (48.6)</td>
</tr>
<tr>
<td>5-6</td>
<td>7 (18.9)</td>
</tr>
<tr>
<td>7+</td>
<td>3 (8.1)</td>
</tr>
</tbody>
</table>

Q13. On average, how many databases do you need to access in order to complete one event report?

Many respondents commented that the number of information sources required completing one event report for HISWA. Despite these comments, the majority of respondents claim to use one or two programs (Table 8).

Table 8. Question 13 - how many information sources are required to complete one event report for HISWA?

<table>
<thead>
<tr>
<th>Average number of sources required</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>2</td>
<td>14 (37.8)</td>
</tr>
<tr>
<td>3</td>
<td>7 (18.9)</td>
</tr>
<tr>
<td>4</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>5+</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>6 (16.2)</td>
</tr>
</tbody>
</table>

Simplicity and Understanding

The following questions asked end-users about their experience in using the HISWA system. Statements regarding the HISWA system were given, and end-users were asked to rank their agreement to the statement using the ranking scale:

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree
- Not Applicable
Q14. The HISWA computer program is easy to use

Whilst the majority of respondents were positive about their experiences whilst using the HISWA computer program (Table 9), one end-user who responded neutrally commented that "It’s not the best system and honestly needs an update"

Table 9. Question 14 - agreement with the statement "The HISWA computer program is easy to use"

<table>
<thead>
<tr>
<th>Response</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>3 (8.1)</td>
</tr>
<tr>
<td>Agree</td>
<td>22 (59.5)</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>10 (27.0)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2 (5.4)</td>
</tr>
</tbody>
</table>

Q15. I can easily update my HISWA data at any time

The majority of respondents agreed with their ability to update their data at any time (Table 10), however, those who did not agree commented on the lack of capacity within the system to delete data and described bugs with the finalising of certain sections.

Table 10. Question 15 - agreement with the statement “I can easily update my HISWA data at any time”

<table>
<thead>
<tr>
<th>Response</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>Neutral</td>
<td>5 (13.5)</td>
</tr>
<tr>
<td>Agree</td>
<td>23 (62.2)</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>5 (13.5)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2 (5.4)</td>
</tr>
</tbody>
</table>

Q16. The HISWA quarterly reports are easy to understand

Although there was a higher proportion of responders disagreeing or being neutral with their opinions on this statement (Table 11), there were no comments to justify as to why they believe this. One end-user who agreed with the statement commented that the reports are "easy for IC staff to understand but others have difficulty”.

Table 11. Question 16 - agreement with the statement "The HISWA quarterly reports are easy to understand"

<table>
<thead>
<tr>
<th>Response</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>3 (8.1)</td>
</tr>
<tr>
<td>Neutral</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>Agree</td>
<td>24 (64.9)</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2 (5.4)</td>
</tr>
</tbody>
</table>
Q17. *I am able to get help if I don’t understand things in the HISWA surveillance manual*

Almost 90% of respondents agreed with this statement – the two non-responders consistently did not respond to questions 14 – 17, and the two neutrals answered neutral or disagree for questions 14-17 (Table 12)

**Table 12.** Question 17 - agreement with the statement “I am able to get help if I don’t understand things in the HISWA surveillance manual”

<table>
<thead>
<tr>
<th>Response</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>Agree</td>
<td>17 (45.9)</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>16 (43.3)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2 (5.4)</td>
</tr>
</tbody>
</table>

Q18. *In your own opinion, the denominator data is simple to collect*

This question asks about the collection of denominator data. For the HISWA system, three types of denominator data are collected – Bed-days, Line-days and Patient months. Not all facilities collect the three different denominator data types, thus the reason behind the high proportion of N/A responses (Table 13). For those who disagreed with the statements for collection of denominator data, comments regarding the retrieval of information from WebPAS being difficult were common.

**Table 13.** Question 18 - agreement with the statement “In your own opinion, the denominator data is simple to collect”

<table>
<thead>
<tr>
<th>Response</th>
<th>Bed-days Count (%)</th>
<th>Line-days Count (%)</th>
<th>Patient-Months Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>1 (2.7)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Disagree</td>
<td>3 (8.1)</td>
<td>4 (10.8)</td>
<td>3 (8.1)</td>
</tr>
<tr>
<td>Neutral</td>
<td>3 (8.1)</td>
<td>6 (16.2)</td>
<td>5 (13.5)</td>
</tr>
<tr>
<td>Agree</td>
<td>15 (40.6)</td>
<td>9 (24.3)</td>
<td>8 (21.7)</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>4 (10.8)</td>
<td>2 (5.4)</td>
<td>1 (2.7)</td>
</tr>
<tr>
<td>Not Applicable</td>
<td>9 (24.3)</td>
<td>14 (37.9)</td>
<td>16 (43.2)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>4 (10.8)</td>
</tr>
</tbody>
</table>

Q19. *In your own opinion, denominator data is simple to report*

Question 19 differs from question 18 as it asked about the reporting of denominator data to HISWA. As per question 18, not all facilities collect the three different denominator data types, thus the reason behind the high proportion of “not applicable” responses (Table 14). There were no comments given to explain the neutral and disagreeing opinions to this statement.
Table 14. Question 19 - agreement with the statement “In your own opinion, the denominator data is simple to report”

<table>
<thead>
<tr>
<th>Response</th>
<th>Bed-days Count (%)</th>
<th>Line-days Count (%)</th>
<th>Patient-Months Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Disagree</td>
<td>2 (5.4)</td>
<td>1 (2.7)</td>
<td>1 (2.7)</td>
</tr>
<tr>
<td>Neutral</td>
<td>2 (5.4)</td>
<td>4 (10.8)</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>Agree</td>
<td>18 (48.6)</td>
<td>14 (37.8)</td>
<td>11 (29.7)</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>7 (18.9)</td>
<td>4 (10.8)</td>
<td>3 (8.1)</td>
</tr>
<tr>
<td>Not Applicable</td>
<td>6 (16.2)</td>
<td>13 (35.1)</td>
<td>15 (40.5)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2 (5.4)</td>
<td>1 (2.7)</td>
<td>3 (8.1)</td>
</tr>
</tbody>
</table>

Q20. If needed, would you know where to find the case definitions used to report for HISWA? Case definitions for the indicators reported to HISWA can be found in the HISWA surveillance manual. It is quite interesting that 4 end-users reported not knowing where to find the case definitions (Table 15), without giving any comment or reason as to why this is so. One of the non-respondents commented that “it depended on what it is” as to whether or not they could find the case definitions for HISWA.

Table 15. Question 20 – does the end-user know where to find the case definitions used to report for HISWA?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>31 (83.8)</td>
</tr>
<tr>
<td>No</td>
<td>4 (10.8)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2 (5.4)</td>
</tr>
</tbody>
</table>

Q21. Is the HISWA system meeting its objectives, as described in the HISWA Surveillance Manual?

Almost 90% of respondents agreed that the HISWA system is meeting its objectives as described in the HISWA surveillance manual (Table 16). The one respondent who did not agree also did not know where to find the case definitions, with the three non-respondents commenting that they are “unable to comment” on whether or not the above statement is true.

Table 16. Question 20 - the HISWA surveillance system is meeting its objectives, as described in the HISWA Surveillance Manual

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>33 (89.2)</td>
</tr>
<tr>
<td>No</td>
<td>1 (2.7)</td>
</tr>
<tr>
<td>Did not respond</td>
<td>3 (8.1)</td>
</tr>
</tbody>
</table>
Reports Generated by HAIU

HAIU generates reports for the end-users every quarter, as well as compiling an annual report. This section of questions were aimed at determining if these reports and the data collected for HISWA are useful, as well as any changes or inclusions that could be made to the reports and/or the data collected.

Q22. Do you use the HISWA data and/or reports to improve infection prevention and control at your facility?

The majority of end-users make use of both the data collected and the reports generated by HAIU (Table 16). Of those who use neither, one commented that “they personally don’t use them, but their facility does” and the other two end-users are from small facilities.

**Table 16.** Question 22 - end-users make use of the HISWA data and/or reports to improve infection prevention and control

<table>
<thead>
<tr>
<th>Use</th>
<th>Count (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data only</td>
<td>2 (5.4)</td>
</tr>
<tr>
<td>Reports only</td>
<td>3 (8.1)</td>
</tr>
<tr>
<td>Both Data and Reports</td>
<td>29 (78.4)</td>
</tr>
<tr>
<td>Neither</td>
<td>3 (8.1)</td>
</tr>
</tbody>
</table>

Open-ended questions

A series of open-ended questions were posed to the end-users for feedback in various areas of the HISWA system. This report summarises the answers into the main findings for each question.

Q23. Are there any other reports that you/your facility would find useful? e.g. Breakdown of SSIs into superficial and deep, trend lines of performance over time

The examples given in the question were the most common answers to this question, along with comparison of data with other hospitals of similar types.

Q25. In your opinion, are there any indicators you believe should be collected for the HISWA surveillance system? e.g. Other significant organisms, other SSIs (such as colorectal, cardiothoracic)

The following answers were suggested as indicators that should be collected or events to take place for HISWA surveillance:

- Cardiothoracic,
- Colorectal surgery,
- CRE and VRE
- Annual invasive device audits
- EBSL Urinary
- Compliance with bundle processes/checklist
- IC nurse visiting other sites
Q26. In your opinion, what are the strengths of the current HISWA computer reporting program?

“User-friendly” and “easy access to data” were the most common answers.

Q27. In your opinion, what are the weaknesses of the current HISWA computer reporting program?

Many end-users commented on the inability to amend errors or submit late data. There were also a lot of descriptions on the faults of the layout and flow of the computer program.

Q28. If the HISWA computer reporting program were to be updated, what changes would you like to be made?

The majority of respondents commented on adding the ability to amend one’s own errors, with several other practical suggestions including being able to view data in spreadsheet format before final submission and incorporating the capacity to extract monthly data for your own Health Care Facility.

Q29. In your own opinion, what are the strengths of the HISWA surveillance system overall?

Benchmarking and comparison to past performance were the two major points that respondents commented on as the strengths of the HISWA surveillance system. There was positive feedback in regards to the reports and the HAIU staff being friendly and available to answer questions.

Q30. In your opinion, what are the weaknesses of the HISWA surveillance system overall?

Many respondents commented that the HISWA surveillance system is resource heavy and time consuming, with all their time spent collecting data with no time to implement change. The inability to comment or provide reasons for increase in infections was also mentioned by several respondents, as infection rates can be influenced by outside factors.

Q31. Are there any other comments/feedback about the HISWA surveillance system you would like to share?

This question allowed for end-users to comment or give feedback on the HISWA surveillance system which wasn’t asked about earlier. The answers given included a lot positive feedback with smiley faces and exclamation marks.
SUMMARY OF EXECUTIVE RESPONSE

Q1. How does your facility use data generated from HISWA?

Data are reported to:

- Quarterly Business Performance Meetings – Regional Executive Committees
- Regional Safety and Quality Committees
- Regional Infection Control Committees
- Infection Control Governance Committee
- Infection Control Advisory Group

Data are communicated back to the clinical workforce via number of mechanisms including:

- Performance dashboard
- Reports emailed to Nurse Director of relevant region
- Infection Control Advisory Group meetings
- Existing communication networks including meetings, intranet, email
- Clinical Essential Training

Q2. Do you find the hospital specific reports useful? Why/why not?

Majority of respondents (8) were aware of the hospital executive summary reports; 2 were not; 1 was unsure. Majority (10) found the reports useful; one responded ‘no’ as had not seen the reports.

Q3. Is HISWA meeting its objectives?

Majority (10) thought HISWA were meeting its objectives (as stated in the HISWA manual); one responded ‘no’ as had not seen the reports.

Q4. Are there any other indicators you believe would be useful for HISWA to collect and report on?

- Given the national standards there is probably a role to play in appropriate antibiotic use rather than focus on infection - the two have an interdependent relationship.
- UTIs
## Appendix 4 – Reports sent using data collected in HISWA

<table>
<thead>
<tr>
<th>Name</th>
<th>Frequency</th>
<th>Scope</th>
<th>Identified</th>
<th>Content</th>
<th>Recipient</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEAT MRSA report</td>
<td>Monthly</td>
<td>All hospitals with EDs that are publicly funded</td>
<td>By HCF</td>
<td>MRSA HAI rate</td>
<td>Senior Data Analyst – Performance Directorate</td>
</tr>
<tr>
<td>Individual Hospital</td>
<td>Quarterly</td>
<td>All public and private HCFs</td>
<td>By HCF</td>
<td>All indicators submitted</td>
<td>ICP via HISWA login</td>
</tr>
<tr>
<td>HISWA Quarterly Aggregate report</td>
<td>Quarterly</td>
<td>All public and private HCFs</td>
<td>Aggregate</td>
<td>All indicators submitted</td>
<td>HISWA / HICWA HAIU website</td>
</tr>
<tr>
<td>Hospital Executive Report</td>
<td>Quarterly</td>
<td>All public and private HCFs</td>
<td>Aggregate</td>
<td>All indicators submitted</td>
<td>CEO/DON each hospital plus relevant HICWA rep</td>
</tr>
<tr>
<td>OS&amp;Q Quarterly report</td>
<td>Quarterly</td>
<td>All public HCFs</td>
<td>By HCF</td>
<td>All indicators submitted</td>
<td>Program Officer OS&amp;Q</td>
</tr>
<tr>
<td>North Metro Quarterly report</td>
<td>Quarterly</td>
<td>All North Metro HCFs</td>
<td>By HCF</td>
<td>All indicators submitted</td>
<td>A/Manager Governance &amp; Performance - NMAHS</td>
</tr>
<tr>
<td>South Metro Quarterly report</td>
<td>Quarterly</td>
<td>All South Metro HCFs</td>
<td>By HCF</td>
<td>All indicators submitted</td>
<td>Manager, Clinical Governance - SMAHS</td>
</tr>
<tr>
<td>Name</td>
<td>Frequency</td>
<td>Scope</td>
<td>Identified</td>
<td>Content</td>
<td>Recipient</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-----------</td>
<td>--------------------------------------------</td>
<td>------------</td>
<td>----------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>WACHS Quarterly report</td>
<td>Quarterly</td>
<td>All WACHS HCFs</td>
<td>By HCF</td>
<td>All indicators submitted</td>
<td>Clinical Review &amp; Audit Analyst - WACHS</td>
</tr>
<tr>
<td>HISWA Annual report</td>
<td>Annually</td>
<td>All public and private HCFs</td>
<td>Aggregate</td>
<td>All indicators submitted</td>
<td>HISWA / HICWA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>By region</td>
<td></td>
<td>HAIU website</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>By size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NHA Performance Indicators</td>
<td>Annually</td>
<td>All public HCFs</td>
<td>Aggregate</td>
<td>S. aureus BSI</td>
<td>AIHW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MyHospital</td>
</tr>
<tr>
<td>WA ABF / KPI</td>
<td>Annually</td>
<td>All public HCFs</td>
<td>By HCF</td>
<td>S. aureus BSI</td>
<td>ABF team and DG and State Health Executive Forum</td>
</tr>
<tr>
<td>ANZICS CLABSI</td>
<td>Monthly</td>
<td>All HISWA HCFs with ICU</td>
<td>By HCF</td>
<td>CLABSI</td>
<td>ANZICS National Surveillance Project</td>
</tr>
<tr>
<td>Quality Composite Score</td>
<td>Quarterly</td>
<td>All public HCFs</td>
<td>By HCF</td>
<td>SABSI, SSI, MRSA</td>
<td>Senior Data Analyst – Performance Directorate</td>
</tr>
</tbody>
</table>
Chapter 4

Investigation of a Pseudo-epidemic of Barmah Forest Virus across Australia
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PROLOGUE

MY ROLE

I was invited by Dr Paul Armstrong to join a Communicable Disease Network Australia (CDNA) working group (WG) investigating a pseudo-epidemic of Barmah Forest virus (BFV). As a member of the WG, I developed meeting agendas, arranged teleconferences, and distributed information and meeting notes. I undertook a survey of the laboratories in Australia to determine the testing procedures for BFV. I wrote a report regarding the activities of the working group along with Dr Armstrong.

In discussion with the WG, I requested notification data from the NNDSS. I analysed the data to determine if there were differences in the demographics for those notified with BFV during the outbreak period when compared to other times.

Whilst this chapter is my own work, it contains material from the report to the CDNA on the activities of the BFV WG written in collaboration with members of the WG, and the PathWest kit evaluation report by written Dr David Smith.

LESSONS LEARNED

This project allowed me to utilise my understanding of laboratory procedures and knowledge of arbovirus epidemiology, especially when designing the laboratory survey. I learnt about collaboration and communication between the public and private laboratories, as well as the importance of the interpretation of case definitions. I also learnt how to analyse line listed notification data, and the coding for STATA to do this.

PUBLIC HEALTH IMPACT

The full impact of this investigation is yet to be seen. However this project improved the wider understanding of the limitations of testing for BFV, revealed discrepancies in the application of the national case definition across Australia, and provided evidence and stimulus to the TGA for the recall of the commercial test kit.

ACKNOWLEDGEMENTS

Tim Sloan-Gardiner, Carolien Giele and Paul Saunders, and the members of the BFV WG:

Dr Paul Armstrong  CDNA  Katrina Knope  Comm. Dept of Health
Dr David Smith  PHLN, NAMAC  Linda Hueston  Arbovirologist, NSW
Dr Allen Cheng  ASID  Anita Williams  MAE Scholar
Peter Markey  NT Dept of Health  A/Prof Martyn Kirk  NCEPH (ANU)
ABSTRACT

Barmah Forest virus (BFV) is an alphavirus, similar to Ross River virus (RRV), but only found in Australia. Symptoms of a BFV infection include arthritis, rash, fatigue, joint pain, myalgia and fever – all of which are similar in presentation to RRV infection, rheumatoid arthritis or other viral infections. Due to the non-specific presentation of BFV there are several potential differential diagnoses to consider.

In October 2012 the number of BFV notifications to the National Notifiable Disease Surveillance System (NNDSS) increased strikingly from October 2012 in locations which are not traditional areas of high arbovirus activity. From anecdotal information, this spike in notifications appeared to result from a faulty commercial serological test kit used by the majority of laboratories across Australia.

A working group to investigate this pseudo-outbreak of BFV was convened by the Communicable Disease Network of Australia (CDNA). Investigations by the working group included a survey of laboratories regarding their testing procedures, several laboratory evaluations of the test kit, and an analysis of NNDSS data from 2001 – 2013.

This chapter is a combined report of two bodies of work; 1) the results from the analysis of notification data for BFV from 1 January 2001 – 31 December 2013, and 2) a report to the CDNA on the findings from the working group investigating the pseudo-outbreak.
## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full text</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASID</td>
<td>Australian Society for Infectious Diseases</td>
</tr>
<tr>
<td>BFV</td>
<td>Barmah Forest virus</td>
</tr>
<tr>
<td>BFV WG</td>
<td>Barmah Forest virus Working Group</td>
</tr>
<tr>
<td>CDNA</td>
<td>Communicable Disease Network Australia</td>
</tr>
<tr>
<td>CHIKV</td>
<td>Chikungunya virus</td>
</tr>
<tr>
<td>EIA</td>
<td>Enzyme immunoassay</td>
</tr>
<tr>
<td>ELISA</td>
<td>Enzyme-linked immunosorbent assay</td>
</tr>
<tr>
<td>HI</td>
<td>haemagglutination inhibition</td>
</tr>
<tr>
<td>ICPMR</td>
<td>Institute for Clinical Pathology and Medical Research</td>
</tr>
<tr>
<td>IFA</td>
<td>Immunofluorescence assay</td>
</tr>
<tr>
<td>Ig</td>
<td>Immunoglobulin</td>
</tr>
<tr>
<td>NAMAC</td>
<td>National Arbovirus and Malaria Advisory Committee</td>
</tr>
<tr>
<td>NCEPH</td>
<td>National Centre for Epidemiology and Public Health</td>
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<tr>
<td>NNDSS</td>
<td>National Notifiable Disease Surveillance System</td>
</tr>
<tr>
<td>NPV</td>
<td>Negative predictive value</td>
</tr>
<tr>
<td>NT</td>
<td>Northern Territory</td>
</tr>
<tr>
<td>PCR</td>
<td>Polymerase chain reaction</td>
</tr>
<tr>
<td>PHLN</td>
<td>Public Health Laboratory Network</td>
</tr>
<tr>
<td>PHU</td>
<td>Public Health Unit</td>
</tr>
<tr>
<td>PPV</td>
<td>Positive predictive value</td>
</tr>
<tr>
<td>RA</td>
<td>Remoteness area</td>
</tr>
<tr>
<td>RRV</td>
<td>Ross River virus</td>
</tr>
<tr>
<td>SA4</td>
<td>Statistical area level 4</td>
</tr>
<tr>
<td>TGA</td>
<td>Therapeutic Goods Administration</td>
</tr>
<tr>
<td>WANIDD</td>
<td>West Australian Notifiable Infectious Diseases Database</td>
</tr>
<tr>
<td>WG</td>
<td>Working group</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

Barmah Forest Virus (BFV) is an *alphavirus* of the Togaviridae family that was first discovered in Victoria in 1974\(^1,2\), with the first human cases reported in 1986\(^3\).

1.1 DISEASE

Of the four *alphaviruses* in Australia, only Ross River virus (RRV) and BFV are known to cause disease in humans\(^4\). The incubation period of BFV is 7-10 days post exposure. While the majority of BFV infections are subclinical and inapparent\(^1\), the clinical presentations include a range of non-specific symptoms including rash, fatigue, joint pain, myalgia and fever. These symptoms are similar in presentation to an RRV infection, mimic rheumatoid arthritis or other viral infections (Table 1 and 2)\(^2,5\).

| **Table 1.** Symptomology and geographic distribution of *alphaviruses* |
|---|---|---|---|---|
| **Alphaviruses** | **Arthralgia** | **Fever** | **Rash** | **Where BFV is endemic** |
| Chikungunya | + | + | + | Middle East, Africa, Asia, Oceania, Australia |
| O’nyong-nyong | + | + | + | East Africa |
| Ross River | + | + | + | Australia, New Zealand, South Pacific Islands |
| Barmah Forest | + | + | + | Australia |
| Sindbis | + | + | + | Europe, Africa, Middle East, Asia, Australia |

| **Table 2.** Symptoms of other common viral infections that cause similar symptoms to infections with *alphaviruses* |
|---|---|---|---|---|
| **Other viruses** | **Arthralgia** | **Fever** | **Rash** | **Other symptoms** |
| Rubella | + | low-grade | + | |
| Parvovirus B19 | + | - | - | |
| Coxsackie viruses | + | + | + | Myalgia |
| Echovirus | + | + | - | Myalgia |

1.2 EPIDEMIOLOGY AND TRANSMISSION

BFV became a nationally notifiable disease in 1995\(^6\). Since then, notifications of infection have been reported in all states and territories across Australia\(^7\). The first outbreak of BFV was reported in the NT in 1992, with subsequent outbreaks in southwest WA in 1993-94\(^8\), NSW in 1995\(^9\) and Victoria in 2000\(^10\). Whilst BFV disease is notifiable in every jurisdiction,
the majority of notifications come from the Australian east coast and the Northern Territory\textsuperscript{6,10}.

BFV is an arbovirus, being transmitted by the female of several mosquito species, including, \textit{Aedes vigilax} and \textit{Culex annulirostris}\textsuperscript{4}. Both BFV and RRV are sustained in mosquito-mammal lifecycles, with the kangaroo being implicated as the main vertebrate host for RRV\textsuperscript{11}. Whilst the viraemia in humans is short lived, previous outbreaks have found the propagation of the virus in a man-mosquito-man cycle\textsuperscript{11}. BFV is known to be endemic in northern Queensland, the NT, and in the southwest and Kimberley regions of WA\textsuperscript{13}. However, disease distribution is only known because of regular mosquito monitoring and enhanced case surveillance\textsuperscript{7}. Molecular epidemiology has found that the circulating BFV strain is homogenous throughout Australia\textsuperscript{12}. The understanding of distribution of BFV is based upon disease notifications and vector monitoring, and because of this, there may be possibility that there is unknown transmission and exposure risk\textsuperscript{13}.

1.2.1 \textit{Effect of Weather}

Areas with traditionally little BFV activity which experience variable weather patterns may experience fluctuations in mosquito abundance. The geographic distribution of mosquito species and their seasonal activity is determined largely by rainfall and temperature. Warmer and wetter conditions may lead to extended vector distribution, habitat, and abundance. For example, a wetter season may increase the abundance of \textit{Ae. camptorhynchus}, the saltmarsh mosquito, a known vector of both BFV and RRV. However, too much rain may potentially flush away larvae or enables their consumption by fish. The effect of climate change on vector-borne disease is complex\textsuperscript{11}.

1.3 \textit{Laboratory Diagnosis}

The current national case definition for a BFV infection requires laboratory evidence without any clinical or epidemiological confirmation (Appendix 1)\textsuperscript{14}. This laboratory evidence can be:

- the isolation of BFV, OR
- the detection of BFV by nucleic acid testing, OR
- IgG seroconversion or a significant increase in antibody level or a fourfold or greater rise in titre to BFV, OR
- detection of BFV-specific IgM, in the absence of RRV IgM, unless BFV IgG is also detected, OR
- detection of BFV-specific IgM in the presence of BFV IgG
The national case definition is based upon the detection of antibodies in serum (serology), as PCR is not a reliable diagnostic test because the virus is not usually present once symptoms develop. Enzyme immunoassays (EIA) are the most common method used for detection of antibodies. Other laboratory methods of diagnosis include neutralisation assays, haemagglutination inhibition (HI) assays and immune-fluorescence assays (IFA), however at present there are only two laboratories in Australia performing these tests, as they are time-consuming and require expertise to read and interpret the results (D Smith, personal comm., Oct 2013).

Immunoglobulin (Ig) M is a marker of recent infection, whilst IgG is a marker of long term immunity. EIA detects IgG and IgM antibodies specific to BFV within a serum sample. A single serological result should not be relied upon as it does not differentiate between current and previous infections. A single IgM positive sample alone does not indicate recent infection; a confirmatory positive IgG result or a 4-fold increase in IgG titre is required, usually taken two weeks after the initial test. Currently confirmatory testing for convalescent IgG is rarely conducted (D Smith, personal comm., Oct 2013).

There is only one commercially available EIA kit for the detection of BFV antibodies, the PanBio EIA IgM kit, which is manufactured by Alere SD. An evaluation performed by Cashman et al., questioned the validity of the commercial EIA kit due to a high false positive rate (19% [7/37]), and suggested the collection of information on travel history and risk exposure be included into the case definition\(^1\). Information regarding the date of onset, clinical presentation and travel history could also be used in making a diagnosis\(^13\).

1.4 BACKGROUND

From October 2012 the rate of BFV notifications noticeably increased across all jurisdictions and peaked in April 2013. These notifications came from areas which did not normally experience arboviral disease, such as metropolitan areas. In many jurisdictions these notifications did not match the geographical distribution of mosquitoes as determined by jurisdictional mosquito surveillance programs and the arboviral surveillance programs of WA and NT did not identify any BFV transmission within mosquito populations in the metropolitan regions.

In July 2013, the CDNA formed the BFV Working Group (WG) to identify reasons for dramatic increases in BFV notifications across Australia. During the first teleconference the fallibility of the commercial test kit used for sero-diagnosis of BFV was question which lead to the survey of laboratories across Australia and the evaluation of the commercial test kit.
2. METHODS

2.1 DATA ANALYSIS

Notification data from January 1 2000 until December 31 2013 were extracted from the NNDSS by the Office of Health Protection at the Commonwealth Department of Health. The data variables received are listed in Table 3. Population data are publicly available from the Australian Bureau of Statistics (ABS) and were downloaded from the website.

Data were divided into two categories:

- Pre-outbreak = from Jan 1, 2001 until September 20, 2012
- Pseudo-outbreak = from October 1, 2012 until December 31, 2013

Table 3. Definitions of data variables received from the National Notifiable Diseases Surveillance System, Australia (as of August 2014)

<table>
<thead>
<tr>
<th>Data type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at onset (years)</td>
<td>The age of the individual as reported to the health authority or the calculated age at onset, using date of birth. In calculating the age in years, the value has been rounded down to the nearest whole year.</td>
</tr>
<tr>
<td>Sex</td>
<td>The current sex of the individual.</td>
</tr>
<tr>
<td>Statistical Area Level 4 (SA4)</td>
<td>SA4s are required to have large populations of over 100,000 people in order to enable accurate estimates. For this reason, in rural areas SA4s generally cover large areas. SA4s are aggregations of whole Statistical Area Level 3 boundaries and fit within whole jurisdictional boundaries.</td>
</tr>
<tr>
<td>Remoteness Areas (RA)</td>
<td>The Remoteness structure comprises of six categories, each of which identifies a non-contiguous region in Australia, being a grouping of Statistical Area Level 1 sharing a particular degree of remoteness. The degree of remoteness was determined using the Accessibility/Remoteness Index of Australia.</td>
</tr>
<tr>
<td>Notifying state or territory</td>
<td>This field contains information on the State / Territory that sends the notification.</td>
</tr>
<tr>
<td>Specimen date</td>
<td>This is the date when the first laboratory specimen was taken.</td>
</tr>
<tr>
<td>Notification received date</td>
<td>This is the date when the notification of disease was received by the communicable diseases section of the relevant health authority.</td>
</tr>
<tr>
<td>NNDSS derived Diagnosis Date</td>
<td>This is the date represents either the onset date or where the date of onset was not known, the earliest of the specimen collection date, the notification date, or the notification receive date.</td>
</tr>
</tbody>
</table>
Table 3 cont. Definitions of data variables received from the National Notifiable Diseases Surveillance System, Australia (as of August 2014)

<table>
<thead>
<tr>
<th>Data type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>True onset date</td>
<td>This is the earliest date the person exhibited symptoms.</td>
</tr>
<tr>
<td>Confirmed status</td>
<td>The confirmation of the disease as per the CDNA case definition.</td>
</tr>
<tr>
<td></td>
<td>According to the BFV case definition, only confirmed cases should be</td>
</tr>
<tr>
<td></td>
<td>notified though the dataset does contain 'probable cases'.</td>
</tr>
</tbody>
</table>

There are several caveats associated with NNDSS data, as they only represent a proportion of the total number of cases occurring in the community. Detailed explanations of associated limitations of NNDSS data are provided in Appendix 7.

The 1 October 2012 was chosen as the arbitrary point as after this date the notification rate increased above what was considered normal. Each variable in the dataset was analysed to determine if there was a difference between pre-outbreak and pseudo-outbreak periods that may indicate that cases occurring during the pseudo-outbreak were different to those prior to the pseudo-outbreak.

Data were received by email and stored in Microsoft Excel. Data were cleaned and analysed using STATA 13.0 (Statacorp, Texas) using appropriate statistical methods, including t-test, z-tests for continuous data. Linear regression and added-variable plots were used to detect trend in notification rates across years. Graphs were produced in Microsoft Excel and STATA 13.0.

Shape files of SLA4 were downloaded from the ABS website. Shape files of SLA4 were downloaded from the ABS website. Maps were created using QGIS desktop version, 2.2.0-Valmiera (GNU General Public License). SLA4 location data were extracted from the provided NNDSS data and converted to a csv file. Annual rates were calculated using ABS population data. Total notified cases per SLA and ranges for the disease rate are represented on each map.

Climate data was obtained from the Australian Bureau of Meteorology website.

2.2 CDNA WORKING GROUP

The BFV WG convened twice by teleconference on 25 July 2013 and 7 November 2013, both with Dr Paul Armstrong as chair of the meeting.

2.2.1 SURVEY OF PUBLIC AND PRIVATE LABORATORIES

In September 2013, an online survey was sent to all jurisdictional CDNA representatives who were requested to distribute the survey to all public and private laboratories within their jurisdictions.
The survey was administered using the Survey Monkey online survey provider to ascertain testing procedures for BFV serological samples, referral patterns of laboratories which do not perform BFV testing, whether laboratories had noticed an increase in positive BFV results, the batch number information of commercially-available tests kits used throughout 2012 and 2013, and the interpretative comments issued with test results to treating doctors (Appendix 2).

2.2.2 PATHWEST LABORATORY EVALUATION

Three laboratory evaluations of the PanBio BFV EIA kit were performed by Dr David Smith at PathWest Laboratory Medicine WA (Appendix 3). The first evaluation was of PanBio EIA BFV-IgM only positives referred to PathWest from a private laboratory for confirmatory testing by IFA, considered to be the gold-standard. The second evaluation was performed using IFA, with samples found to be BFV-IgM only positive from a different private laboratory. A third more complete evaluation was performed in August 2013 to compare the PanBio BFV IgM EIA kit with the PathWest Laboratory in-house HI and IFA-IgM tests.

Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the PanBio EIA kit were determined by Dr David Smith. The evaluation included 100 samples negative for HI and IFA IgM antibodies to RRV, BFV and Chikungunya virus (CHIKV) (ie. ‘true negative’ samples); 30 samples positive for BFV IgM by IFA and HI, 30 samples positive for RRV IgM, and 30 samples positive for CHIKV IgM (ie. ‘true positive’ samples). Where results were conflicting, the original tests were repeated.

2.2.3 COLLATION OF JURISDICTION-SPECIFIC STUDIES

2.2.3.1 Victorian case investigations
The Victoria Department of Health performed investigations into the notifications of BFV in Victoria by investigating the confirmed and rejected notifications of BFV to the Health Department according to the case definition, looking at the epidemiology and location of the case.

2.2.3.2 Northern Territory case series
The NT Department of Health performed follow-up on 79 cases of BFV from early 2013 (a sample of convenience) and assessed them against two formulated cases definitions for an acute arboviral infection; one that was specific and one that was broader (Appendix 4)

2.2.3.3 Mosquito surveillance
Interviews were conducted with coordinators of mosquito surveillance programs in NT and WA by members of the CDNA.
Figure 1. Notifications of BFV infection by month and year of diagnosis and state or territory, Australia, 2008 to 2013 (NNDSS supplied data, May 2014)
3. RESULTS

3.1.1 NUMBER OF NOTIFICATIONS

From 1 Jan 2001 until 30 September 2012 (pre-outbreak), there were 17,634 notifications of BFV to NNDSS, with an approximate average annual notification rate of 1,469 notifications per year (Figure 1, previous page). From 1 October 2012 until 31 December 2013 (pseudo-outbreak), there were 4,910 notifications of BFV to NNDSS, more than three times the average mean notification rate for the last 12 years (Figure 2).

Figure 2. Number of notifications of BFV pre-outbreak and during the pseudo-outbreak (NNDSS supplied data, May 2014)

3.1.2 SEX

Across the whole study period, more females were notified with BFV than males, 51.5% (n = 11,605) compared to 48.5% (n = 10,926). However, when those notifications made during the pseudo-outbreak were removed from analysis, more men (n = 8,937; 50.7%) were notified than women (n = 8,684; 49.3%). During the pseudo-outbreak period, women were 1.4 times more likely to be notified with BFV than men (RR 1.4, 95%CI 1.3 – 1.5, p <0.01).

3.1.3 AGE

The age of those who were notified during the pseudo-outbreak were significantly lower than pre-outbreak. The mean age of cases notified pre-outbreak was 42.1 years, which was significantly lower than the mean of 44.8 years for people notified during the pseudo-outbreak (p <0.01). There were significantly more notifications from those in the 10-19, 20-29 and 40-49-year age groups, and significantly less notifications of those aged
between 50-59 and 60-69 ($p < 0.05$). There was no statistical difference in the other age groups (Figure 3).

![Histogram of 10-year age groups for pre-outbreak and during the pseudo-outbreak](image)

**Figure 3.** Histogram of 10-year age groups for pre-outbreak and during the pseudo-outbreak (NNDSS supplied data, May 2014)

### 3.1.4 Jurisdictions

The proportion of notifications across the eight jurisdictions were statistically different pre-outbreak when compared to during the pseudo-outbreak ($p < 0.01$). There were significantly less notifications from NSW ($p < 0.01$), and significantly more in both the NT and WA ($p < 0.01$). The rate of BFV notifications per 100,000 persons reflects these findings (Figure 4). Individual charts for each jurisdiction are presented in Appendix 5.

### 3.1.5 Remoteness and Statistical Area Level

Notifications from major cities increased significantly during the pseudo-outbreak. In 2013, 45% of BFV notifications came from people residing with metropolitan areas. Maps 1 and 2 illustrate the change in rate of BFV notifications in each SLA4, with increases along the east coast from Newcastle to Cairns, including metropolitan Brisbane, as well as in Darwin and southwest WA. Rate change data for each SLA4 is provided in Appendix 5.

### 3.1.6 Effect of Weather

Overall, the summer of 2012-13 was the warmest on record nationally. The annual rainfall was slightly below average inland and east, whilst above average for the east coast, northern Tasmania and parts of WA. There were flooding events along the east coast in northern NSW and tropical Queensland – both of these areas experienced increased rate of notifications during the pseudo-outbreak, as seen in Map 2. Whilst these events do not detract from the fallibility of the EIA kit, it may represent an increase in true cases.
Figure 4. Rate of Barmah Forest notifications per 100,000 persons for each jurisdiction, 2003 – 2013 (NNDSS supplied data, May 2014)

Figure 5. Rate of Barmah Forest notifications per 100,000 persons for each remoteness area, 2003 – 2013 (NNDSS supplied data, May 2014)
Map 1. Mean annual notification rate 2001 – 2012, for BFV by statistical area level 4 per 100,000 populations. Data obtained from ABS and NNDSS (2014)
Map 2. Mean annual notification rate 2013, for BFV by statistical area level 4 per 100,000 populations. Data obtained from ABS and NNDSS (2014)
3.1.7 **Collation of Jurisdiction-Specific Studies**

3.1.7.1 **Mosquito surveillance**
Details of mosquito surveillance programs for each jurisdiction were obtained and are listed in Table 4. Mosquito surveillance is routinely carried out in most jurisdictions.

Two jurisdictions - WA and NT - noted that the pattern of notifications did not match the distribution of BFV mosquito vectors, nor were they identifying any BFV within mosquito populations in the metropolitan regions (C Johansen & P Markey, personal comm., Jan 2014).

3.1.7.2 **Victorian case investigations**
Of the confirmed cases in Victorian endemic areas with IgM+/IgG- results, none of the 22 cases had clinically compatible symptoms with epidemiological links. There were a further 28 cases with IgM+/IgG- results, and seven of these had a low positive IgM result. Victoria Health Department rejected a further 32 cases based upon several clinical and epidemiological indicators. Of 25 re-bleeds performed, there were no cases of seroconversion demonstrated (B Sutton, personal comm., July 2013).

3.1.7.3 **Northern Territory case series**
The NT found that approximately 26% (confirmed and probable cases combined) reported symptoms compatible with an acute infection when marked against their specific case definition and that approximately 47% of cases reported symptoms compatible with an acute infection when marked against their broader case definition (P Markey, personal comm., July 2013) (Appendix 5).

3.1.8 **Survey of Public and Private Laboratories**
Overall, 29 laboratories responded to the survey; 14 from NSW, four each from Queensland and Tasmania, three from Victoria, two from South Australia and one each from ACT and WA. The response rate was unable to be calculated as the number of laboratories that received the survey and did not participate is unknown. However, if the number of laboratories accredited by NATA for serological testing is used as the denominator, it could be estimated that the response rate to this survey to be 29.9%\(^{15}\).

From those laboratories that responded, 20 laboratories specified they referred specimens for BFV testing to other laboratories, and nine laboratories performed testing in-house. Of the nine laboratories that performed testing in-house who responded to the survey, eight indicated they use the Alere PanBio EIA kit.
Table 4. Mosquito surveillance programs for each jurisdiction – information supplied by the National Arbovirus and Malaria Advisory Committee (NAMAC)

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NSW</strong></td>
<td>New South Wales Arbovirus Surveillance and Vector Monitoring Program: mosquito trapping occurs from mid-spring to mid-autumn (November to April)</td>
</tr>
<tr>
<td><strong>NT</strong></td>
<td>Northern Territory Mosquito Borne Disease Control Program: 21 trapping sites throughout Darwin urban area, six traps in Nhulunbuy, three in Tennant Creek, four in Katherine, three in Alyangula on Groote Eylandt, and six in Alice Springs</td>
</tr>
<tr>
<td><strong>Queensland</strong></td>
<td>Mosquito monitoring is performed by some local councils. Opportunistic trapping is carried out by the University of Queensland, the Tropical Public Health Unit network within Queensland Health and Queensland Institute of Medical Research</td>
</tr>
<tr>
<td><strong>SA</strong></td>
<td>Mosquito surveillance and control activities are conducted in partnership between South Australia Health, University of SA, Local Government and Biosecurity SA</td>
</tr>
<tr>
<td><strong>Tasmania</strong></td>
<td>No state-wide systematic mosquito abundance, virus isolation or sentinel animal surveillance activities are undertaken due to the relatively low risk of arbovirus transmission in the state. However, mosquito collections are undertaken in Sorell Council region during high risk periods over January to March</td>
</tr>
<tr>
<td><strong>Victoria</strong></td>
<td>Eight councils undertake mosquito surveillance as part of the standard mosquito monitoring program; six councils are located along the Murray River; one is a coastal site and the other is within metropolitan Melbourne. Additional mosquito surveillance also occurs in the Geelong area. The mosquitoes are collected weekly as part of the standard program and sent on cold storage to Department of Environment and Primary Industries for identification, enumeration and virus isolation.</td>
</tr>
<tr>
<td><strong>WA</strong></td>
<td>Mosquito trapping is undertaken by the UWA Arbovirus Surveillance and Research Laboratory (ASRL) in collaboration with the Mosquito-borne Disease Control group of WA Health</td>
</tr>
</tbody>
</table>
Five of the eight laboratories that used the PanBio kit reported an increase in positive and/or borderline positive results since early 2013. One laboratory reported an increase of borderline positives from 2.5% in 2012 to 9.5% in 2013. One laboratory provided primary test data, showing a sharp increase in both positive and borderline positive (equivocal) results from November 2012, peaking at 47% positive in March 2013, without a return to baseline (Figure 6).

Batch numbers were provided by six of the eight laboratories using the PanBio kit. Identical batches appear to have been used during the increase of BFV notifications from October 2012 – March 2013. Interpretative comments issued with test results were provided by eight of the nine responding laboratories in this survey. A detailed summary of results from the survey is provided in Appendix 6.

![Figure 6. Number of IgM positive and borderline data provided by one of the private laboratories which used the Alere PanBio BFV EIA kit, November 2012 - June 2013](image)

### 3.1.9 **PathWest Laboratory Evaluation**

The first laboratory evaluation of PanBio EIA BFV-IgM only positives referred to PathWest for confirmatory testing showed 0/47 were confirmed by IFA, indicating a false positive rate of 100%. The second evaluation, with a further 24 samples referred to PathWest, were also all negative for BFV IgM by IFA.

The third evaluation compared the PanBio kit with HI and IFA for BFV, RRV and CHIKV. The BFV-IgM EIA detected 29/30 IFA BFV-IgM positive samples, yielding a sensitivity of 96.7% (95% CI 80.9 – 99.8%). All 160 samples were negative for BFV IgM by IFA, and the analysis yielded a specificity of 96.9% (95% CI 92.5-98.8%). As the specificity for the all IgM negative samples and the samples containing RRV-IgM or CHIKV-IgM were similar,
the analysis was pooled and yielded a specificity of 96.9% (95% CI 92.5-98.8%). The BFV-IgM EIA detected 29/30 IFA BFV-IgM positive samples, yielding sensitivity of 96.7% (95% CI 80.9 – 99.8%) (Table 5).

Table 5. IFA-IgM and EIA BFV-IgM results from the third laboratory evaluation

<table>
<thead>
<tr>
<th>IFA-IgM status</th>
<th>EIA BFV-IGM Signal/Cut-off ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ratio ≤ 1.0</td>
</tr>
<tr>
<td>BFV</td>
<td>RRV</td>
</tr>
<tr>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Neg</td>
<td>Pos</td>
</tr>
<tr>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

Using a prevalence of genuine (or ‘true positive’) IgM of 1% in the population being tested (ie. the positivity rate for samples from WA patients sent directly to PathWest over this period), the PPV for the PanBio EIA IgM is estimated at 24.0%, and the NPV at 99.9%. It is important to note that the batches of the test kits used in this evaluation were not the same batches implicated in the increase of positive results from October 2012. Notwithstanding, the results of this evaluation reveals that under normal circumstances the kit meets the prescribed manufacturers specifications. A full report of the results is provided in Appendix 4. However, it should be noted that the batches of PanBio BFV IgM EIA kits used in this laboratory evaluation are not the same as those used by the laboratories during the pseudo-outbreak, and as such, the results may be different.

4. DISCUSSION

This investigation aimed to determine the reason/s for the pseudo-outbreak of BFV and if a specific demographic pattern would support that a pseudo-outbreak of BFV was occurring. This may then act as an early warning system for future increases in BFV notifications outside of the norm.

4.1 ANALYSIS OF NNDSS DATA

Most arboviral infections occur seasonally; in Australia the peak season is December – March. As the beginning of this outbreak occurred outside of the traditional season for arboviral infections, it was thought important to compare whole year data rather than just during the peak season. The mean notification rate was used for comparison of notifications across Australia, years and outbreak periods to take into account the variation of populations within states and across time.
4.1.1 Age and Sex

Flexman et al., states that the typical age range for alphaviruses infection is between 20 – 60 years, with illness uncommon in children\(^\text{13}\). In reports of previous BFV outbreaks, the age and sex distribution have been similar to the typical range. In the 2002 outbreak in the Gippsland region in Victoria, there were 23 males and 24 females interviewed, with 51% of the cases aged between 20-49 years\(^9\). In a retrospective analysis of notifications from 1993-2003 reported in Queensland, 71% of those notified with BFV were aged between 30 and 59 years\(^16\).

In this analysis there were statistically significant differences in the age and sex of those notified with BFV during the pseudo-outbreak when compared to the previous 12 years. Whilst the median age of notifications in this analysis were significantly lower for those notified during the pseudo-outbreak, the interquartile range of notifications was 28 – 54 years, which is within the typical range of 20-60 years suggested by Flexman et al\(^\text{13}\).

4.1.2 Geographic Distribution

The majority of notifications during the pseudo-outbreak originated from metropolitan areas (44.6%). Whilst there was an increase in the number of notifications from outer regional and rural Australia, the analysis of geographic distribution of any arboviral disease is affected by several issues.

4.1.2.1 Reporting

Using the residential postcode of cases to plot incidence may misrepresent the true location of exposure, leading to inaccurate understanding of the disease distribution and epidemiology\(^7,\text{13}\). Ehkles et al. interviewed 30 people notified with BFV in the Hunter New England region. Whilst 22 cases lived within a known endemic BFV region, seven the 30 did not, but reported being bitten by mosquitoes when in an endemic region\(^7\).

Enhanced case surveillance regarding travel history or risk exposure would increase the knowledge of exposure and the understanding of disease distribution\(^7,\text{17,18}\). Areas which showed a decrease in BFV notifications during the pseudo-outbreak performed enhanced case surveillance to confirm the diagnosis, for example, the Victorian case investigations\(^\text{19}\). However, the current NNDSS database would not be capable of maintaining such information, and such data would better serve the local jurisdictions in awareness of current arbovirus activity.

4.1.2.2 Serological Testing

Serological diagnosis of BFV is subject to certain limitations including high false-positive rate and the need to confirm recent infection through demonstrated seroconversion\(^\text{13}\). It
should be noted that not all jurisdictions report IgM+ only results, which would impact the proportion of notifications. In Victoria, IgM+ only notifications are followed up and second serological samples are requested to demonstrate seroconversion. Consequently, false notifications in the surveillance system are not as common in Victoria\textsuperscript{19}.

As exposure history or symptom onset data is not routinely collected, people with persisting symptoms may be tested after the acute phase of the disease and be wrongly classified as occurring during the off-season\textsuperscript{18}. It is less common for BFV symptoms to persist than RRV, however Flexman \textit{et al.} states that at least 10\% of cases have joint pain for more than 6 months\textsuperscript{13}.

4.1.2.3 \textit{Natural habitat and vector distribution}

The range of mosquito species confirmed as vectors of BFV is wide and similar to RRV, with the majority of important vector species being associated with coastal wetlands, saltmarshes and swamplands\textsuperscript{7}. \textit{Aedes notoscriptus}, which is an urban mosquito, has also been demonstrated to be a competent vector for BFV in laboratory experiments\textsuperscript{20}. People living within 3-5 km of saltmarshes or wetlands are at a greater risk of being exposed to BFV\textsuperscript{21}.

There is uncertainty as to what the natural reservoir of BFV in Australia is. Whilst low levels of neutralising antibodies have been detected in kangaroos, wallabies, possums, horses, dogs and cats after experimental infection, the detected circulating virus level is considered too low for mosquitoes to be infected with the virus when bitten. The genetic similarity of BFV strains across Australia suggests an avian or bat host\textsuperscript{7}. The disease may be introduced into a region through mosquitoes, viraemic humans/stock, birds, or some other animal host. This may be one explanation of the change in geographic distribution.

4.2 \textbf{Changing the National Case Definition}

Methods to improve the specificity of the current national case definition include requiring a second convalescent serological sample, or the inclusion of clinical evidence of typical symptoms of a BFV infection. Revisions of the national case definition are currently being considered by the National Case Definition WG of CDNA.

4.2.1 \textit{Requiring Second Convalescent Sample}

The change of the national case definition to require either the seroconversion to BFV IgG+ (if the primary result was BFV IgM+ only) or a 4-fold increase in BFV IgG titre from original titre (if the primary result was BFV IgM+/IgG+) in the absence of RRV IgM appears on the surface to be a simpler choice than the introduction of clinical evidence, but still increases the specificity of the case definition and reduces the potential of false
positive notifications. Changes to automated notifications and/or decision trees by laboratories for notifying results to jurisdictional notification databases would be required; however, the difficulty of this depends upon the set-up of data delivery by the laboratories to the jurisdiction. More importantly, requiring a second sample depends on the patients returning for a second test and the Doctors being willing to ask their patient to have the second test.

4.2.2 Inclusion of Clinical Evidence

Currently BFV is a laboratory-notified disease, with positive IgM results submitted to the jurisdictional health department directly. For example, currently in WA, BFV notifications are submitted to the Western Australia Notifiable Infections Disease Database (WANIDD) through automated downloads from testing laboratories and instantly set as “confirmed” status.

As previously recommended by Cashman et al., the national case definition could be changed so that clinical symptoms of fever with either rash or joint pain would be included in the levels of evidence for a diagnosis of BFV. Changes to the case definition requiring diagnosing clinicians’ submitting evidence or a Public Health Unit (PHU) following up a case for information would require changes to the operation of jurisdictional notification databases. At present, notifiable diseases that require further information to submit a notification are often under-reported.

4.2.3 Effect on Previous Notifications

Should the case definition of BFV be changed to increase the specificity, a decision would need to be made as to whether it is retrospectively applied from October 2012 in order to remove false-positive results from NNDSS, “clean up” the data and re-calibrate the 5-year rolling mean (which is often used as the baseline rate to determine outbreaks). However, the data required to apply the new case definition may not exist within NNDSS (ie, clinical evidence and/or IgG results) and therefore potentially true cases may be removed. Caveats for NNDSS BFV notification data from October 2012 until the end of 2013 should be applied so that any future analysis of the data from that period would take into account this pseudo-outbreak.

4.2.4 Effect on Other Alphaviruses

As mentioned in the introduction, RRV is very similar to BFV in both physiological and epidemiological determinants. Therefore, any change to the national case definition of BFV to include clinical indicators or a secondary IgG results could also be considered for the national case definition for RRV.
4.3 **PathWest Laboratory Evaluation**

While the sensitivity and specificity of the test kit batch evaluated by PathWest Laboratory were in keeping with the manufacturer's description, the population who are tested for BFV-IgM have a low pre-test probability of true infection, estimated at less than 1%, yielding a low PPV of 24%. Subsequently, most positive tests using the PanBio IgM test kit are likely to be false positive results. Therefore, the PanBio BFV IgM EIA test kit is not fit for the purpose of the detection of genuine IgM to BFV in populations with a very low risk (i.e. pre-test probability) of infection. It should be noted that in the absence of IgM in the PanBio EIA test has a very high NPV, and so is fit for exclusion of genuine IgM in this population.

As the known distribution of BFV is only within Australia, the commercial competition for producing testing kits is low. Because of this, Alere PanBio is the only manufacturer of a commercial test kit for BFV IgM and/or IgG. Other methods of testing for BFV are more expensive, time consuming and require a certain level of expertise which private laboratories may not have. As mentioned earlier, two laboratories in Australia do perform alternative methods of testing serum for BFV IgM. A potential possibility to reduce the false-positive rate would be the referral of positive samples to one of the two laboratories that don’t use the PanBio kit for confirmation of results. Whilst this suggestion is physically feasible – one laboratory in NSW and one in WA could cover all jurisdictions – it is unlikely to occur, as political and financial reasons, such as who would fund the confirmatory test as it would not be covered by Medicare, would obstruct such measures being introduced. The referral of tests for confirmation would also affect the timeliness of the results and subsequent notifications, which could impact upon public health action.

4.4 **Online Survey Results**

Whilst the response rate was potentially quite low (it is unknown how many laboratories the survey was distributed to), the results provided insight into the BFV WG as to how many laboratories use the PanBio kit, which batches were used during the time period of increased notifications, and the standard interpretive comments included in reports sent to requesting practitioners regarding serological BFV results.

4.4.1.1 **Batch Use**

The increase of notifications seen from October 2012 which peaked in March 2013 correlated with the use of batch numbers recalled by Alere in September 2013 (Appendix 3).
4.4.1.2 Interpretive Comments
Whilst differing in length, the overall message of a second sample being required for confirmation was consistent in seven of the eight interpretive comments for BFV IgM+/IgG-, RRV IgM-/IgG- results (Appendix 3).

4.5 RECALLS BY ALERE
The Therapeutic Goods Administration (TGA) are responsible for ensuring the tests kits used for diagnosis within Australia are safe and fit for their intended purposes under the Therapeutic Goods Act 1989. At the time of investigation, the TGA were approached by the working group in order to assist in the investigation into the reliability of the test kit.

In September 2013 a recall was made by Alere, the manufacturer of the PanBio BFV kits (TGA recall issue: RC-2013-RN-00967-1), citing that these kits “may yield an increased number of false-positives”23. Alere claims to have performed a validation for the performance of the PanBio EIA kit in concordance with the method provided in the kits instructions for use, and states that previous investigations have shown that the use of the PanBio kit on automated platforms may further increase the proportion of false-positive results. Alere indicates that any changes made to the test method, including the use of automated platforms, must be validated “in-house” (i.e., specifically for the laboratory performing the testing according to their method) in accordance with the laboratories quality assurance guidelines23.

In the communication with laboratories, Alere claimed that “testing of the affected lots with internal QC samples has shown that their performance is consistent with product manufactured over the past several years. However, after testing of these lots with newly sourced, characterised reference samples, it is concluded that there has been a shift in the seroepidemiology of the patient population that is currently being tested. The issue has been corrected for future lots by adjusting the assay cut-off” [Alere recall notice, unpublished work, 13 Sept 2013].

A second recall of the BFV kit took place in October 2013 (TGA recall issue: RC-2013-RN-01106-1), involving the batches which replaced those from the primary recall25. Alere states in the recall notice that “internal investigations of the affected lot number indicate that the performance of this lot may change over time leading to an increased number of false positive results”, specifically a decrease in the long-term stability of the positive control24.

Both of the recalls by Alere were made in consultation with the TGA. The TGA deemed the recalls as Class II recalls where “the product deficiency could cause illness, injury or result
in mistreatment”, but not potentially life-threatening or leading to a serious risk to health\textsuperscript{25}.

### 4.5.1 Other Arboviruses

The quality of the PanBio EIA kit for other arboviruses, particularly for RRV, was questioned by the BFV WG during discussions, as it is possible that the reduction in quality also affects the diagnosis of other arboviruses by EIA. In April 2013, the PanBio Dengue IgM EIA kit was recalled (TGA RC-2013-RN-00358-1) due to “complaints of invalid test runs due to results falling outside the cut-off value customer acceptance range leading to an invalid test”\textsuperscript{26}. Any evaluation of arbovirus test kits should take into consideration whether there are other diagnostic methods and/or commercial test kits available (e.g., Meddens DEB-ELISA for RRV) which should also be included in any evaluation.

### 4.6 Public Health Action

Individual jurisdictions advised the clinicians and laboratories regarding the interpretation of results from the PanBio BFV EIA test kit. In WA, letters describing the potential issue of false positive results and thereby suggesting that “a diagnosis should not be made unless a convalescent sample is taken and seroconversion or a rising IgG is demonstrated, or the result is confirmed by a different method” were sent to the heads of laboratories (P Armstrong, person comm., October 2013).

Public health action against arboviruses is currently based upon notification numbers, mosquito investigations and statistical modelling. PHUs currently work with local governments to implement mosquito reduction programs. Warning statements are released to the media to inform people when and where there is an increased risk of mosquito-borne disease exposure and provide information for mosquito-bite avoidance.

In the event of a true epidemic of any mosquito-borne disease in Australia, the epidemiology of disease transmission within mosquitoes would be evident. Actions which could be taken in this event include the implementations of programs to reduce the numbers of mosquito larvae and their breeding sites, fogging the mosquito adults, rezoning of land-use to prevent human habitation within mosquito-dense areas, and building regulation changes to require the installation of flyscreens on doors and windows.
5. CONCLUSION AND RECOMMENDATIONS

From the results of the analysis of NNDSS data, it is clear that health agencies should investigate the accuracy of BFV notification data when the mean age of notifications decreases and the proportion of females being notified increases. Changes in the geographic distribution of BFV should be investigated in conjunction with vector and animal host studies to determine the possibility of BFV transmission within metropolitan and urban areas. The effect of weather should be further investigated to determine the influence on geographic distribution of vectors. For future “outbreaks” if BFV, the demographic and geographical distribution of mosquitoes needs to be analysed and compared with the “pseudo-outbreak” data of this study.

The evidence collated in this investigation suggests that the poorly performing Alere EIA test kit lead to an increase in false positive IgM results and thereby an increase in BFV notifications. This can only be surmised, as the batches in question were not evaluated. In the laboratory evaluation conducted by PathWest, the sensitivity and specificity of the Alere EIA IgM kits was within the parameters stated by the manufacturer, however, because the pre-test probability of a person being tested for BFV infection is so low (estimated by PathWest to be <1%), the PPV is very low, meaning that the rate false positive results will be high. The Alere (formerly PanBio) EIA test kits have had a chequered history, with at least two episodes in the past three decades where the performance became substandard. With this all in mind, the notification of BFV from a single IgM result should be interpreted with caution.”

5.1 RECOMMENDATIONS

These recommendations have been put forward to the BFV WG for further consideration. It should also be noted that the findings from this report formed the basis for a briefing for the CDNA, who were in a position to decide what further action was required.

**Recommendation 1: That samples that are unclear are referred for confirmation**

Neutralisation assays, HI assays and IFAs are considered to be the gold-standard for alphavirus antibody detection. Whilst the commercial EIA kit has been validated against these methods, in some circumstances a sample is “borderline” or equivocal, that is, near the optical density (OD) cut-off point for a positive result. Throughout the pseudo-outbreak we saw an increase in these samples. We recommend that laboratories send samples that are unclear or have OD readings that are close to the cut off to a reference laboratory for confirmation.
Recommendation 2: That there is an analysis of mosquito and virus distribution data for the same period

In this analysis we observed a shift in the geographic distribution of notifications across the 12-year study period. However, relying solely upon notification data to understand the distribution of arboviruses is fraught with issues, as discussed previously. To fully understand the shift in geographical distribution, jurisdictions should consider collating and analysing mosquito trap site data and compared to human case numbers using geographical information system (GIS) software to determine if the virus distribution has also shifted.

Recommendation 3: That the Department clean and/or produce caveats for the 2012/2013 data for future analysis

If the case definition of BFV is changed to require a second sample, it may be applied retrospectively from October 2012 to “clean up” the data and re-calibrate the 5-year rolling mean. However, if this data is not available, caveats for NNDSS BFV notification data from October 2012 until the end of 2013 could be applied for future analysis.

Recommendation 4: That a validation of commercial kit for RRV diagnosis is performed

Selvey et al questioned the fallibility of the RRV commercial test, stating “it is clear that detection of IgM in the absence of IgG using the commercial EIA test should be interpreted with caution as there is a high chance that it is a false positive”. As the method of antibody detection is the same as that for BFV, it is reasonable to assume that there may be issues with the reliability of antibody detection and should be evaluated against the gold-standard methods.
6. REFERENCES


154
7. APPENDICES

APPENDIX 1 – NATIONAL CASE DEFINITION FOR BARMAH FOREST VIRUS INFECTION, EFFECTIVE 1 JANUARY 2013

REPORTING

Only a confirmed case should be notified.

CONFIRMED CASE

A confirmed case requires laboratory definitive evidence only.

LABORATORY DEFINITIVE EVIDENCE

Isolation of Barmah Forest virus

OR

Detection of Barmah Forest virus by nucleic acid testing

OR

IgG seroconversion or a significant increase in antibody level or a fourfold or greater rise in titre to Barmah Forest virus

OR

Detection of Barmah Forest virus-specific IgM, in the absence of Ross River virus IgM, unless Barmah Forest virus IgG is also detected

OR

Detection of Barmah Forest virus-specific IgM in the presence of Barmah Forest virus IgG
APPENDIX 2 – SURVEY OF LABORATORIES FOR TESTING AND REPORTING OF BARMAH FOREST VIRUS

This year it has been noted that there is an Australian-wide increase of Barmah Forest virus (BFV) notifications and laboratory reports compared with previous years with considerable variability across the jurisdictions.

Investigations to date suggest that the poor performance of the only available commercial test kit for Barmah Forest Virus serology testing is at least partially responsible.

The Communicable Disease Network of Australia is seeking further information about the testing and criteria for reporting of BFV and about any concerns you may have about the performance of your test kits.

This brief survey seeks to obtain information to determine the extent of this problem and determine its possible causes.

1. Do you test for BFV infection at your laboratory?
   ☐ Yes (go to question 3)
   ☐ No (go to question 2)

2. If you answered NO to question 1, to which laboratory(ies) do you refer specimens for BFV IgM testing?
   ____________________________________________________________
   ____________________________________________________________

The following questions need only be answered if you answered YES to question 1

3. What test kits/methods do you currently use for BFV IgM?
   ☐ PanBio
   ☐ Other commercial assay: __________________________________________
   ☐ In-house assay, specify: __________________________________________

4. If using the PanBio kit, what batch number(s) is/are you currently using?
   __________________________________________________________________

5. On what date did you start using these batches? ____/_____/_____

6. What automated platform do you use for performing your EIA tests?
7. On what date did you start using this equipment? ____/____/_____

8. Have you noticed any increase in the rate of IgM positivity any problems with your BFV-IgM assays?

Yes ☐ (go to question 9)

No ☐ (go to question 11)

9. If you answered YES to question 8, was the change noticed at any particular date? ____/____/_____

10. Are you able to provide any more details about the nature of the changes (e.g. increase in number of IgM positives, the percentage positive rates, the signal/cutoff ratios)?

__________________________________________________________________________

__________________________________________________________________________

11. If using the PanBio kit, do you follow the result interpretation guidelines as per the kit insert? Yes ☐ No ☐

12. Which of the following criteria do you use for Barmah Forest (BFV) IgM results:
   a. to report to a requesting doctor that results are consistent with recent infection?

   ☐ IgM alone
   What comment do you add? ____________________________________________________________

   ☐ both IgM and IgG
   What comment do you add? ____________________________________________________________

   ☐ seroconversion or a rise in IgG on paired samples

   b. for notification to state Health Departments (as per local public health legislation) that results are consistent with recent infection?

   ☐ IgM alone

   ☐ both IgM and IgG

   ☐ seroconversion or a rise in IgG on paired samples
Thank you for completing this section of the survey. If you are not participating in the extended survey (see below) then please submit your survey response.
We are seeking some more detailed information from laboratories that are willing and able to participate. If you are interested, would you please answer the following questions about your ability and willingness to provide this?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Not available</td>
</tr>
</tbody>
</table>

1A. Are you willing to send patient serum samples to the state PHLN lab for further testing?

If YES:

- a. Samples from the past year?
- b. Samples from previous years?
- c. IgM positive, IgG negative samples?
- d. IgM positive, IgG positive samples?

2A. The previous batch numbers for up to the last five years, including inclusive dates when these batches were used?

3A. The percentage positive rates for current and past BFV-IgM testing, ideally for the last five years and by kit batch number?

4A. The information for up to the last five years regarding the number/proportion that are IgM+/IgG – and IgM+/IgG +?

If you are happy to assist but do not have the resources available to get the information and/or samples, please contact (insert name and details)

Once completed please fax or scan and email the survey to (insert name and details)

Many thanks for your assistance with this
APPENDIX 3 – LABORATORY EVALUATION OF THE PANBIO EIA FOR THE DETECTION OF BARMAH FOREST VIRUS IgM

Background: In WA, the number of notifications of BFV infection to the Department of Health for late 2012 and early 2013 was dramatically higher than that seen in previous years and was at the same level as RRV notifications. Most of these notifications occurred in areas without other evidence to suggest increased BFV activity, and were based on the detection of IgM to BFV in the absence of IgG using the PanBio EIA test. Furthermore testing at PathWest using an in-house HI test and an IFA-IgM was showing the usual low rates of positive tests. Similar experiences with this test were subsequently identified in other jurisdictions. Laboratories varied in whether they notified BFV-IgM only samples, so that this problem was reflected to varying extents in the jurisdictional notification figures.

The possibility that these may be false positive IgM results was investigated as false positive results may lead to patient misdiagnosis as well as inaccuracies in disease notification.

Current Status: An initial evaluation of PanBio EIA BFV-IgM only positives referred to PathWest for confirmatory testing showed that 0/47 confirmed, indicating a false positive rate of 100%.

PathWest undertook an evaluation of the PanBio BFV IgM EIA kit in comparison with their in-house HI and IFA-IgM tests. The specificity evaluation included 100 samples negative for HI and IFA IgM antibodies to Ross River virus (RRV), Barmah Forest virus (BFV) and chikungunya virus (CHIKV), 30 samples positive for BFV IgM by IFA and HI, 30 samples positive for RRV IgM, and 30 samples positive for CHIKV IgM Where results were conflicting, the original tests were repeated

Sensitivity: The BFV-IgM EIA detected 29/30 IFA BFV-IgM positive samples, yielding sensitivity (95% CI) of 96.7% (80.9 – 99.8%)

Specificity: 160 samples were negative for BFV IgM by IFA

<table>
<thead>
<tr>
<th>IFA-IgM status</th>
<th>EIA BFV-IGM Signal/Cutoff ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>BFV RRV CHIKV</td>
<td>Ratio ≤ 1.0</td>
</tr>
<tr>
<td>Neg Neg Neg</td>
<td>97</td>
</tr>
<tr>
<td>Neg Pos Neg</td>
<td>29</td>
</tr>
<tr>
<td>Neg Neg Pos</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>155</td>
</tr>
</tbody>
</table>
As the specificity for the all IgM negative samples and the samples containing RRV-IgM or CHIKV-IgM are similar, the analysis has been pooled and yielded a specificity of 96.9% (92.5-98.8%)

This data cannot be used to calculate the positive and negative predictive values, as the samples are not representative of the population who have diagnostic samples taken (ie they have been specifically chosen you have more positive patients than are present in our diagnostic population.

The positive rate for samples from WA patients sent directly to PathWest over this period of time was <1%. Using a prevalence of genuine (or 'true positive') IgM of 1% in the population being tested, the predictive values for the PanBio EIA IgM are estimated to be:

Positive predictive value (PPV): 24.0%

Negative predictive value (NPV): 99.97%

In some populations (eg the Perth metropolitan area) the prevalence of genuine BFV IgM is much lower than 1% and the PPV would be therefore be lower than 24.0%.

In summary, the performance of the PanBio EIA IgM was similar to that described by the manufacturer. However, the population who are tested for BFV-IgM have a very low prevalence of true positive IgM, yielding a very low positive predictive value. Therefore, the test is not fit for one of its purposes i.e. the detection of genuine IgM to BFV in populations with a very low risk (ie. pre-test probability) of infection. Supporting evidence is required before a reactive IgM on this test can be interpreted as indicating recent or recent past BFV infection.

The absence of IgM in the PanBio EIA test has a very high negative predictive value, so the test is fit for exclusion of genuine IgM in this population.
APPENDIX 4 – INVESTIGATION CASE DEFINITIONS USE BY THE NORTHERN TERRITORY

1) Clinical case definition for acute infection (specific)

Overview
An acute illness characterised by polyarthralgia and often but not always associated with fever, polyarthritis, rash, myalgia, lymphadenopathy and fatigue.

Definition
Onset later than 4 weeks before the test, AND
Peak of disease within 4 days of onset (arbitrary definition of acute), AND
Pain in more than one small joint (ie excludes knees, elbows and hips), AND
At least 2 of the following:
  - Fever
  - Evidence of arthritis – redness, heat or swelling in at least one joint.
  - Rash
  - Myalgia – muscle pain as distinct from joint pain
  - Lymphadenopathy

Probable
Same as above except only need one of the list at the end, OR
Same as above with 2 from the list but pain restricted to only large joints (but >1 joint)

2) Clinical case definition for acute infection (broad)

Overview
An acute illness characterised by polyarthralgia and often but not always associated with fever, and rash.

Definition
Onset later than 8 weeks before the test, AND
At least 2 of the following:
  - Fever
  - Rash
  - Polyarthralgia
Appendix 5 – Additional Tables and Graphs from Analysis of NNDSS BFV Notification Data

Figure 1. 10 year age distribution for BFV notifications for each year, 2001 – 2013

Table 1. Notifications of BFV to the NNDSS per jurisdiction for each year, 2001 - 2013

<table>
<thead>
<tr>
<th>Year</th>
<th>ACT</th>
<th>NSW</th>
<th>NT</th>
<th>QLD</th>
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<th>TAS</th>
<th>VIC</th>
<th>WA</th>
<th>Total</th>
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<td>4</td>
<td>0</td>
<td>58</td>
<td>44</td>
<td>920</td>
</tr>
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<td>3</td>
<td>53</td>
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<td>471</td>
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<td>210</td>
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<td>76</td>
<td>3</td>
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<td>1,200</td>
<td>11,905</td>
<td>691</td>
<td>13</td>
<td>601</td>
<td>2,370</td>
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</table>
Figure 2. Rate of notifications per 100,000 persons for the Northern Territory, 2003 – 2013

Figure 3. Rate of notifications per 100,000 persons for New South Wales, 2003 – 2013

Figure 4. Rate of notifications per 100,000 persons for Western Australia, 2003 – 2013
Figure 5. Rate of notifications per 100,000 persons for Queensland, 2003 – 2013

Figure 6. Rate of notifications per 100,000 persons for South Australia, 2003 – 2013

Figure 7. Rate of notifications per 100,000 persons for Tasmania, Victoria and the ACT, 2003 – 2013
Table 3. Change in rates for each SLA4 in Australia, 2001 - 2013

<table>
<thead>
<tr>
<th>SLA4</th>
<th>01-12</th>
<th>2013</th>
<th>difference</th>
<th>SLA4</th>
<th>01-12</th>
<th>2013</th>
<th>difference</th>
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<td>Adelaide - Central and Hills</td>
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<td>0.00</td>
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<td>Moreton Bay - N</td>
<td>2.40</td>
<td>8.33</td>
<td>increased</td>
</tr>
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<td>0.13</td>
<td>0.00</td>
<td>decreased</td>
<td>Moreton Bay - S</td>
<td>1.95</td>
<td>2.94</td>
<td>increased</td>
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<tr>
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<td>0.12</td>
<td>0.00</td>
<td>decreased</td>
<td>Mornington Peninsula</td>
<td>0.02</td>
<td>0.27</td>
<td>increased</td>
</tr>
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<td>Adelaide - W</td>
<td>0.07</td>
<td>0.00</td>
<td>decreased</td>
<td>Murray</td>
<td>0.59</td>
<td>1.34</td>
<td>increased</td>
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<td>ACT</td>
<td>0.09</td>
<td>0.00</td>
<td>decreased</td>
<td>New England/NW</td>
<td>0.63</td>
<td>2.91</td>
<td>increased</td>
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<tr>
<td>Ballarat</td>
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<td>0.00</td>
<td>decreased</td>
<td>Newcastle/ Lake Macquarie</td>
<td>0.54</td>
<td>0.63</td>
<td>increased</td>
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<td>Barossa - Yorke</td>
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<td>0.00</td>
<td>decreased</td>
<td>North West</td>
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<td>0.00</td>
<td>decreased</td>
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<td>NT - Outback</td>
<td>2.76</td>
<td>11.04</td>
<td>increased</td>
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<td>Brisbane - E</td>
<td>1.41</td>
<td>3.75</td>
<td>increased</td>
<td>Other Territories</td>
<td>37.71</td>
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<td>increased</td>
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<td>0.30</td>
<td>0.43</td>
<td>increased</td>
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<td>increased</td>
<td>Perth - NE</td>
<td>0.39</td>
<td>1.54</td>
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<td>Brisbane - W</td>
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<td>Perth - NW</td>
<td>0.35</td>
<td>1.26</td>
<td>increased</td>
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<td>0.93</td>
<td>0.62</td>
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<td>0.50</td>
<td>1.24</td>
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</tr>
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<td>Bunbury</td>
<td>1.50</td>
<td>4.43</td>
<td>increased</td>
<td>Perth - SW</td>
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<td>2.86</td>
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<td>Cairns</td>
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<td>11.32</td>
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<td>SA - Outback</td>
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<td>decreased</td>
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<td>0.19</td>
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<td>0.00</td>
<td>decreased</td>
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<td>increased</td>
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<td>0.00</td>
<td>decreased</td>
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<td>9.21</td>
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<td>Warrnambool/SW</td>
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<td>0.00</td>
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<td>0.00</td>
<td>decreased</td>
<td>West/ North West</td>
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<td>0.00</td>
<td>no change</td>
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<td>0.00</td>
<td>decreased</td>
<td>WA - Outback</td>
<td>1.23</td>
<td>3.91</td>
<td>increased</td>
</tr>
<tr>
<td>Melbourne - W</td>
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<td>0.00</td>
<td>decreased</td>
<td>WA - Wheat Belt</td>
<td>0.74</td>
<td>2.24</td>
<td>increased</td>
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<td>8.74</td>
<td>increased</td>
<td>Wide Bay</td>
<td>2.21</td>
<td>6.98</td>
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</table>
APPENDIX 6 – REPORT ON FINDINGS FROM BFV LABORATORY

SURVEY

Thirty-four people completed the survey representing twenty-nine laboratories; 14 from NSW, 4 each from Queensland and Tasmania, 3 from Victoria, 2 from SA and 1 each from ACT and WA. Table 1 provides an overview of responses to the survey from those laboratories that perform BFV serology testing. Below are the results collected from the survey in response to the questions, which lists the responses from each laboratory that indicated it performed BFV testing.

1. Do you test for BFV infection at your laboratory?
Of the 29 laboratories represented in the survey, 20 referred the test to other laboratories and 9 performed the BFV serology. Laboratories have been de-identified and labelled Lab A – I (Table 1).

2. If you answered No, which laboratory do you refer your specimens to?
Laboratories which respondents indicated they referred their samples to include:

- Douglass Hanly Moir (NSW)
- Healthscope Pathology (VIC)
- ICPMR, Westmead (NSW)
- Pathology North (NSW)
- Pathology Queensland
- Pathology West
- Sullivan Nicholaides Pathology (QLD)
- VIDRL (VIC)
- Viral Diagnostic and Referral Laboratory (NSW)

3. What test kits/methods do you currently use to test for BFV IgM?
Seven of the nine laboratories that perform testing report using the Alere BFV kit. One laboratory reports performing Indirect ELISA using PanBio BFV microtitre wells, whilst the other reports using antibody class capture ELISA incorporating monoclonal antibodies.

4. Do you use and automated platform to perform your EIA tests? If you do use a platform to perform your EIA tests, which platform do you use? On what date did you start using this platform?
There appears to be no association in regards to self-reported increase in positives and those who use an automated platform (Table 1).
5. If you keep records of batch numbers used over time, please list those used since July 2012 along with dates they were used (if available). If no information is available, please write N/A

Table 2 provides batch numbers and dates (where supplied) used in the laboratories which perform BFV testing. The increase of notifications seen from October 2012 which peaked in March 2013 correlates with the use of batch number 12114.

6. Within the past 12 months, have you noticed any unexpected increase in the rate of IgM positivity with your BFV assay? If YES, when was this increase first noticed?

Are you able to provide any more details about the nature of the changes (e.g. increase in number of IgM positives, the percentage positive rates, the signal/cutoff ratios)?

Five laboratories indicated a noticed increase in BFV positive rates (Table 1), with the additional information supplied:

- Lab C expressed that they had seen a “significant increase in the number of equivocal/low positive Barmah Forest Virus IgMs” as well as a “significant increase in the number of IgM positive samples that failed to seroconvert to IgG upon parallel testing with a second sample”
- Lab I said their BFV IgM Bord/Pos with BFV IgG Negative specimens have increased from 2.5 % in 2012 to 9.5% for 2013.
- Lab D said they had noticed an “increased percentage positivity rate”
- Lab E provided laboratory percentage data

7. If using the PanBio kit, did you follow the result interpretation guidelines as per the previous kit insert?

All laboratories that use the PanBio kit indicate that they follow the results interpretation guidelines.

8. The caveat on the bottom of laboratory reports

Table 2 lists the responses from the laboratories for this question (Please note that the table is split).

9. Would you be willing to participate?

The laboratories B, D, G, H and I indicated their willingness to participate in further investigations of the rise in BFV.
<table>
<thead>
<tr>
<th>Laboratory</th>
<th>State</th>
<th>Test</th>
<th>Platform</th>
<th>Platform Start date</th>
<th>Did you notice an increase?</th>
<th>When?</th>
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<tr>
<td>A</td>
<td>NSW</td>
<td>Antibody class capture ELISA incorporating monoclonal antibodies</td>
<td>Triturus</td>
<td>2002</td>
<td>No</td>
<td>--</td>
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<tr>
<td>B</td>
<td>Qld</td>
<td>PanBio (Alere)</td>
<td>Evolis</td>
<td>2005</td>
<td>No</td>
<td>--</td>
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<tr>
<td>C</td>
<td>Qld</td>
<td>PanBio (Alere)</td>
<td>Tecan EVOlyzer</td>
<td>2008</td>
<td>Yes</td>
<td>02/01/2013</td>
</tr>
<tr>
<td>E</td>
<td>WA</td>
<td>PanBio (Alere)</td>
<td>No</td>
<td>N/A</td>
<td>Yes</td>
<td>12/01/2012</td>
</tr>
<tr>
<td>F</td>
<td>Qld</td>
<td>Indirect ELISA using PanBio BFV (Alere) microtitre wells</td>
<td>No</td>
<td>N/A</td>
<td>Yes</td>
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<tr>
<td>G</td>
<td>NSW</td>
<td>PanBio (Alere)</td>
<td>Aausku SQ II</td>
<td>2013</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>H</td>
<td>NSW</td>
<td>PanBio (Alere)</td>
<td>No</td>
<td>N/A</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>J</td>
<td>NSW</td>
<td>PanBio (Alere)</td>
<td>BEP 2000</td>
<td>2002</td>
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</table>

N/A in the platform start date as those laboratories do not use an automated platform. -- in the “when” column indicate that no response was provided, as the laboratory did not report a noticed increase in IgM positivity rates.
Table 2. Reported list of batches used by laboratories that indicated they tested for BFV in the online survey

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<thead>
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<th>Laboratory</th>
<th>Batch Numbers</th>
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</tr>
</thead>
<tbody>
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<td>B</td>
<td>11335</td>
<td>05/04/12 – 26/09/12</td>
</tr>
<tr>
<td></td>
<td>12115</td>
<td>27/04/12 – 08/03/13</td>
</tr>
<tr>
<td></td>
<td>12354</td>
<td>09/03/13 – 19/05/13</td>
</tr>
<tr>
<td></td>
<td>15051</td>
<td>20/05/03 – 20/08/13</td>
</tr>
<tr>
<td>H</td>
<td>IgM 11335</td>
<td>2/7/12 – 5/10/12</td>
</tr>
<tr>
<td></td>
<td>IgM 12114</td>
<td>12/10/12 – 5/4/13</td>
</tr>
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<td></td>
<td>IgM 12354</td>
<td>12/4/13 – 13/6/13</td>
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<tr>
<td></td>
<td>IgM 13051</td>
<td>17/6/13 – 13/9/13</td>
</tr>
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<td></td>
<td>IgM 13234</td>
<td>19/9/13 – 27/9/13</td>
</tr>
<tr>
<td></td>
<td>IgG 12039</td>
<td>2/7/12 – 29/12/12</td>
</tr>
<tr>
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<td>27/09/2013 – current</td>
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</table>
Table 3. Responses from laboratories that indicate they perform BFV testing to question 14:

“What standard interpretative comments do you include your reports to a requesting practitioner that results are consistent with recent infection?”

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<th>B</th>
<th>G</th>
<th>C</th>
<th>E</th>
<th>F</th>
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</thead>
<tbody>
<tr>
<td><strong>IgM+/IgG- (BFV); IgM+/IgG- (RRV)</strong></td>
<td>Serology may indicate recent infection with Ross River or Barmah Forest virus or false positive / non-specific stimulation of IgM.</td>
<td>Recent BFV send convalescent</td>
<td>In view of the positive Ross River Virus IgM, these results should be interpreted with caution. Please repeat in 14 days.</td>
<td>This profile may be consistent with either: The presence of an IgM response to both Ross River virus and Barmah Forest virus.</td>
</tr>
<tr>
<td><strong>IgM+/IgG- (BFV); IgM+/IgG+ (RRV)</strong></td>
<td>Serological evidence of recent Ross River virus infection.</td>
<td>Recent BFV send convalescent</td>
<td>In view of the positive Ross River Virus IgM, these results should be interpreted with caution. Please repeat in 14 days.</td>
<td>This profile may be consistent with either: The presence of an IgM response to both Ross River virus and Barmah Forest virus.</td>
</tr>
<tr>
<td><strong>IgM+/IgG- (BFV); IgM-/IgG- (RRV)</strong></td>
<td>Serology may indicate recent infection with Barmah Forest virus or false positive / non-specific stimulation of IgM.</td>
<td>Recent BFV send convalescent</td>
<td>These results are suggestive of either early infection, or false positive/cross reactive antibody. Please repeat in 14 days.</td>
<td>This profile may be consistent with either: Suggestive evidence of recent Barmah Forest virus (BFV).</td>
</tr>
<tr>
<td><strong>IgM+/IgG- (BFV); IgM-/IgG+ (RRV)</strong></td>
<td>Serology may indicate recent infection with Barmah Forest virus or false positive / non-specific stimulation of IgM.</td>
<td>Recent BFV send convalescent</td>
<td>These results are suggestive of either early infection, or false positive/cross reactive antibody. Please repeat in 14 days.</td>
<td>This profile may be consistent with either: Suggestive evidence of recent Barmah Forest virus (BFV).</td>
</tr>
<tr>
<td><strong>IgM+/IgG+ (BFV)</strong></td>
<td>Serology may indicate recent infection with Barmah Forest virus or false positive / non-specific stimulation of IgM. Serological evidence of past infection with Ross River virus.</td>
<td>Recent BFV send convalescent</td>
<td>Suggestive of recent infection. In a minority of cases, the IgM response persists beyond 6 months.</td>
<td>This profile may be consistent with either: Result consistent with current Barmah Forest Virus (BFV).</td>
</tr>
<tr>
<td>Seroconversion or a rise in BFV IgG on paired samples</td>
<td>Serological evidence of recent Barmah Forest virus infection.</td>
<td>Recent or Past BFV tested</td>
<td>Tested in parallel with the specimen submitted on... Seroconversion noted. Consistent with recent infection. (Similar comment applied to rise in IgG on paired samples).</td>
<td>IgG seroconversion has occurred since the previous test on (insert date). Seroconversion consistent with acute BFV infection.</td>
</tr>
<tr>
<td>IgM+/IgG- (BFV); IgM+/IgG- (RRV)</td>
<td>IgM+/IgG- (BFV); IgM+/IgG- (RRV)</td>
<td>IgM+/IgG- (BFV); IgM+/IgG- (RRV)</td>
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<tr>
<td>Serological evidence consistent with current or recent Barmah Forest virus infection. False positive IgM results may occur and infection should be confirmed by demonstration of a rising IgG level in a follow up sample collected in 10-14 days. IgM antibodies may persist for over 12 months.</td>
<td>To determine the significance of these results please provide another serum sample in 14 to 21 days to demonstrate a rise in IgM and/or IgG seroconversion. When submitting additional samples please provide clinical and travel history as this assists interpretation. For further information please contact</td>
<td>An isolated IgM positive for BFV and RRV may represent a false positive result, and must be interpreted against the clinical presentation and exposure history. To confirm diagnosis, repeat serology for IgM and IgG in 2-3 weeks is recommended.</td>
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<tr>
<th>IgM+/IgG- (BFV); IgM+/IgG+ (RRV)</th>
<th>IgM+/IgG- (BFV); IgM+/IgG+ (RRV)</th>
<th>IgM+/IgG- (BFV); IgM+/IgG+ (RRV)</th>
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<tr>
<td>Serological evidence consistent with current or recent Barmah Forest virus infection. False positive IgM results may occur and infection should be confirmed by demonstration of a rising IgG level in a follow up sample collected in 10-14 days. IgM antibodies may persist for over 12 months.</td>
<td>To determine the significance of these results please provide another serum sample in 14 to 21 days to demonstrate a rise in IgM and/or IgG seroconversion. When submitting additional samples please provide clinical and travel history as this assists interpretation. For further information please contact</td>
<td>An isolated IgM positive for Barmah Forest virus (BFV) may represent a false positive result, and must be interpreted against the clinical presentation and exposure history. To confirm diagnosis, repeat serology for IgM and IgG in 2-3 weeks is recommended. A single sample with both IgM and IgG positive for Ross River Virus (RRV) may represent either acute or past infection as both IgM and IgG may persist for years following infection. Further serological testing is not helpful. A copy of this report will be forwarded to the Public Health Unit.</td>
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<tr>
<th>IgM+/IgG- (BFV); IgM-/IgG- (RRV)</th>
<th>IgM+/IgG- (BFV); IgM-/IgG- (RRV)</th>
<th>IgM+/IgG- (BFV); IgM-/IgG- (RRV)</th>
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<tr>
<td>Serological evidence consistent with current or recent Barmah Forest virus infection. False positive IgM results may occur and infection should be confirmed by demonstration of a rising IgG level in a follow up sample collected in 10-14 days. IgM antibodies may persist for over 12 months.</td>
<td>These results provide presumptive evidence of early BFV infection. However, to confirm the result and to exclude the possibility of a false positive IgM we require another sample to be submitted at least 14 to 21 days post onset to demonstrate IgG seroconversion. If submitting additional samples please provide clinical and travel history as this assists interpretation. If you have questions or concerns please contact</td>
<td>An isolated IgM positive for Barmah Forest virus (BFV) may represent a false positive result, and must be interpreted against the clinical presentation and exposure history. To confirm diagnosis, repeat serology for IgM and IgG in 2-3 weeks is recommended.</td>
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<tr>
<td><strong>IgM+/IgG- (BFV); IgM-/IgG+ (RRV)</strong></td>
<td>Serological evidence consistent with current or recent Barmah Forest virus infection. False positive IgM results may occur and infection should be confirmed by demonstration of a rising IgG level in a follow up sample collected in 10-14 days. IgM antibodies may persist for over 12 months.</td>
<td>The BFV results provide presumptive evidence of early BFV infection. However, to confirm the result and to exclude the possibility of a false positive IgM we require another sample to be submitted at least 14 to 21 days post onset to demonstrate IgG seroconversion. If submitting additional samples please provide clinical and travel history as this assists interpretation. The RRV results suggest past infection with RRV or another closely related alphavirus. If you have questions or concerns please contact.</td>
</tr>
<tr>
<td><strong>IgM+/IgG+ (BFV)</strong></td>
<td>Serological evidence consistent with current or recent Barmah Forest virus infection. False positive IgM results may occur and infection should be confirmed by demonstration of a rising IgG level in a follow up sample collected in 10-14 days. IgM antibodies may persist for over 12 months.</td>
<td>These results provide presumptive evidence of recent BFV infection.</td>
</tr>
<tr>
<td>Seroconversion or a rise in BFV IgG on paired samples</td>
<td>N/A</td>
<td>An isolated IgM positive for Barmah Forest virus (BFV) may represent a false positive result, and must be interpreted against the clinical presentation and exposure history. To confirm diagnosis, repeat serology for IgM and IgG in 2-3 weeks is recommended. Consistent with a previous Ross River virus infection.</td>
</tr>
</tbody>
</table>

An isolated IgM positive for Barmah Forest virus (BFV) may represent a false positive result, and must be interpreted against the clinical presentation and exposure history. To confirm diagnosis, repeat serology for IgM and IgG in 2-3 weeks is recommended. Consistent with a previous Ross River virus infection.
Appendix 7 – NNDSS Data Caveats

National Notifiable Diseases Surveillance System

Williams Request – May 2014

Data Caveats

It should be noted there are several caveats to the requested National Notifiable Diseases Surveillance System (NNDSS) data:

General

- A major limitation of the notification data is that, for most diseases, they represent only a proportion of the total cases occurring in the community, that is, only those cases for which health care was sought, a test conducted and a diagnosis made, followed by a notification to health authorities. The degree of under-representation of all cases is unknown and is most likely variable by disease and jurisdiction.

- From 1 January 2009, the Communicable Diseases Network Australia implemented the Cross-border NNDSS Notification Protocol. The Protocol establishes that notifications are reported by the jurisdiction of residence, regardless of the jurisdiction of diagnosis. In the instance that a case is usually resident overseas, the notification is reported to the NNDSS by the jurisdiction of diagnosis. Data collected prior to the implementation of the protocol may therefore include unknown numbers of dual notifications in the NNDSS.

- ‘Diagnosis date’ was used to define the period of analysis. This date represents either the onset date or where the date of onset was not known, the earliest of the specimen collection date, the notification date, or the notification receive date.

- In interpreting these data it is important to note that changes in notifications over time may not solely reflect changes in disease prevalence or incidence. Changes in testing policies; screening programs, including the preferential testing of high risk populations; the use of less invasive and more sensitive diagnostic tests; and periodic awareness campaigns, may influence the number of notifications that occur over time.

- Data for publication should be aggregated to ensure data cells containing fewer than 5 in the numerator are not published.

Case Definition and Notification to the NNDSS

- The current case definition for Barmah Forest Virus (BFV), including any historical edits, is available at: https://www.health.gov.au/casedefinitions

- In September 2003, new national case definitions for notifications reported to NNDSS were endorsed by the Communicable Diseases Network Australia, with nearly all jurisdictions implementing the new definitions in January 2004 (New South Wales commenced in August 2004). Prior to the adoption of the national definitions, some jurisdictions used the 1994 NHMRC case definitions, some jurisdictions used modified definitions that were based on the NHMRC case definitions, and some others used definitions specific to the state for some diseases.
• BFV became nationally notifiable in 1995. Northern Territory has been notifying BFV cases to NNDSS since 1997.
• The requester will be aware of the issues with the potential for false positive diagnosis of BFV cases, since this relates to the project aims. However, it is worth noting that National Arbovirus and Malaria Advisory Committee advice is that a single positive IgM test result may be insufficient to give reasonable certainty of the notification being a true case, and further changes to the surveillance case definition may be recommended in the near future to require a re-bleed for confirmation.

**Age at onset (years)**
- The age of the individual as reported to the health authority or the calculated age at onset, using date of birth. In calculating the age in years, the value has been rounded down to the nearest whole year.

**Sex**
- The current sex of the individual.

**Statistical Area Level 4 (SA4) & Remoteness Areas (RA)**
- Since 2011 the Australian Statistical Geography Standard (ASGS) superseded the Australian Statistical Geographical Classification (ASGC) and as a result of this change we only use ASGS correspondence files.
- SA4 and RA are as per the current ABS correspondence files. Please note that as there is not a precise one-to-one conversion from postcode to either SA4 and/or RA, we use the correspondence file to create a conversion file and determine the SA4 and/or RA which has the highest proportion identified to a single postcode.

**Notifying state or territory**
- This field contains information on the State / Territory that sends the notification.

**Specimen date**
- This is the date when the first laboratory specimen was taken.

**Notification received date**
- This is the date when the notification of disease was received by the communicable diseases section of the relevant health authority.

**NNDSS derived Diagnosis Date**
- This is the date represents either the onset date or where the date of onset was not known, the earliest of the specimen collection date, the notification date, or the notification receive date.

**True onset date**
- This is the earliest date the person exhibited symptoms.

**Confirmed status**
- The confirmation of the disease as per the CDNA case definition. According to the BFV case definition, only confirmed cases should be notified though the dataset does contain 'probable cases'.
Chapter 5

Outbreak Investigations
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PROLOGUE

MRSA

My Role

I was approached by Alison Peterson (AP) in June 2013 to assist in the investigation of a cluster of cases of CA-MRSA. With the assistance of AP, I created a questionnaire on EpiInfo, and I compiled data from PathWest, questionnaire, and from the local PHU. With assistance from the outbreak team, I wrote and collated the report for this outbreak.

Lessons Learned

This outbreak investigation was a collaborative effort between the HAIU at CDCD, the Wheatbelt PHU and an independent infection prevention and control professional. From this, I gained insight into the structure of the WA Health Department and the separation between the West Australian Country Health Service (WACHS) and the CDCD. I gained skills in working as part of a multi-disciplinary team, particularly regarding the importance of maintaining good communication between all team members and understanding the politics behind particular situations.

Technically, I cemented the skills learnt at course-block regarding questionnaire design, EpiInfo and outbreak investigations. I discovered that not all outbreak investigations follow a classical "10 step" design.

Public Health Impact

This outbreak highlighted the importance of infection prevention and control in occupational health and safety procedures, especially in high risk environments. Also, this outbreak identified a need for a co-ordinated approach for the distribution of information about management of MRSA decolonisation to prevent further transmission.

Acknowledgements

Dr Naru Pal, Anne Foyer, Megan Reilly, Julie Pearson, Dr Geoffrey Coombs, Alison Peterson
Norovirus

My Role

I was asked by Dr Barry Combs in December 2013 to assist in the investigation of this outbreak. I performed the interviews and collated the data. I also lead the writing of the final report.

Lessons Learned

As this was my first foodborne outbreak investigation, I quickly learnt that you need to respond quickly to assess the risk of ongoing infection and gather information to assist public health action. I also came to understand and appreciate the importance of good communication and collaboration between agencies involved, especially when separated by vast distances, such as between the CDC in Perth and agencies in the Kimberley, where the outbreak occurred.

Public Health Impact

This outbreak highlighted the importance of formal food handling and hygiene training for all food handling staff, including transient staff, and ensuring that ill staff members are excluded from food handling for a period of 48 hours post-cessation of symptoms.

Acknowledgements

Dr Pippa Chigdzey, Dr Barry Combs, Ginny Montinero, Emma Caitlin, and Melanie Houghton
ABSTRACT

MRSA

Methicillin-resistant *Staphylococcus aureus*, or MRSA, is a notifiable infection in WA. Specific strains of MRSA are known to be community-acquired (CA-MRSA). This report discusses a cluster of CA-MRSA cases associated with an abattoir.

NOROVIRUS

On 9 December 2013, the Kimberley Population Health Unit contacted the OzFoodNet at CDCD to assist in investigating reports of an outbreak of diarrhoea and vomiting after six people attended the emergency department following eating at a hotel restaurant.
## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full text</th>
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<tbody>
<tr>
<td>ACCESS</td>
<td>Australian Collaborating Centre for <em>Enterococcus</em> and <em>Staphylococcus</em> species</td>
</tr>
<tr>
<td>AP</td>
<td>Alison Peterson</td>
</tr>
<tr>
<td>AW</td>
<td>Anita Williams</td>
</tr>
<tr>
<td>BC</td>
<td>Dr Barry Combs</td>
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<tr>
<td>CA-MRSA</td>
<td>Community-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
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<tr>
<td>CDCD</td>
<td>Communicable Disease Control Directorate</td>
</tr>
<tr>
<td>D&amp;V</td>
<td>Diarrhoea and vomiting</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
</tr>
<tr>
<td>EC</td>
<td>Emma Caitlin</td>
</tr>
<tr>
<td>ED</td>
<td>Emergency department</td>
</tr>
<tr>
<td>EHO</td>
<td>Environmental health officer</td>
</tr>
<tr>
<td>GP</td>
<td>General Practitioner</td>
</tr>
<tr>
<td>HAIU</td>
<td>Healthcare Associated Infection Unit</td>
</tr>
<tr>
<td>IPCC</td>
<td>Infection prevention and control consultant</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>KPHU</td>
<td>Kimberley Public Health Unit</td>
</tr>
<tr>
<td>LA-MRSA</td>
<td>Livestock-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>MO</td>
<td>Medical officer</td>
</tr>
<tr>
<td>MRSA</td>
<td>Methicillin-resistant <em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>OFN</td>
<td>OzFoodNet</td>
</tr>
<tr>
<td>PC</td>
<td>Dr Pippa Chidzey</td>
</tr>
<tr>
<td>PCR</td>
<td>Polymerase chain reaction</td>
</tr>
<tr>
<td>PHU</td>
<td>Public Health Unit</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal protective equipment</td>
</tr>
<tr>
<td>PVL</td>
<td>Panton-Valentine leukocidin</td>
</tr>
<tr>
<td>WACHS</td>
<td>West Australian Country Health Service</td>
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</table>
1. AN OUTBREAK OF COMMUNITY-ASSOCIATED MRSA IN ABATTOIR WORKERS

1.1 INTRODUCTION

Community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA) infections are now prevalent in Australia and many other parts of the world\(^1\). CA-MRSA strains have adapted to survive and spread efficiently in the community and can cause infections in healthy people who have not had exposure to healthcare systems. CA-MRSA can also be carried asymptomatically as normal flora in the nose, throat, axillae, and groin regions. CA-MRSA primarily causes skin and soft tissue infections, but severe invasive infections including necrotising pneumonia, bacteraemia, osteomyelitis, endocarditis, pyomyositis and septic arthritis have also been reported\(^2,3\). Transmission of CA-MRSA is typically through direct infection, close and/or prolonged contact with carriers, tight living quarters, prolonged contact with carriers or poor personal hygiene\(^4\)\(^-\)\(^7\). Outbreaks of CA-MRSA have been reported in different groups of people including sportsmen, school children, military personnel, healthcare workers, and intravenous drug users\(^8\)\(^-\)\(^12\).

Since the early 1980s, methicillin-resistant *S. aureus* (MRSA) has been a notifiable organism in WA via laboratory notification. The WA Department of Health promotes a comprehensive state-wide MRSA management policy throughout, based on selective screening, isolation and decolonisation of patients and healthcare workers\(^13\). As part of this policy all MRSA isolates in WA are referred to the Australian Collaborating Centre for *Enterococcus* and *Staphylococcus* species (ACCESS) Typing and Research for strain characterisation.

In 2012-13 CA-MRSA accounted for 85% of all MRSA isolated in WA\(^14\), with the ST93-IV MRSA strain, colloquially known as the Queensland (Qld) clone, was one of the most prevalent CA-MRSA strains characterised\(^2\)\(^,\)\(^15\) and is well established as a community-associated strain throughout Australia\(^3\). The ST93-IV MRSA strain carries genes for the Panton-Valentine leukocidin (PVL), a toxin associated with white cell destruction and abscess formation\(^2\)\(^,\)\(^3\).

In this report, we describe an outbreak of ST93-IV MRSA strain in a group of residents linked to an abattoir located outside a country town in Western Australia. The abattoir employs people from the town and the surrounding areas, as well as itinerant workers, many of whom share accommodation. These workers often use sharp knives and/ or equipment with sharp edges that put them at high risk for injuries, particularly cuts to the hands, wrists and fingers.
In May 2013, several employees from the abattoir presented to the Emergency Department (ED) of the local hospital with wound infections following workplace injuries, which subsequently tested positive for MRSA. In June 2013, the infection control nurse at the local hospital alerted management at the abattoir and the local Public Health Unit (PHU), who recommended the appointment of an independent infection prevention and control consultant (IPCC) to advise the abattoir on infection prevention and control practices at the facility. The Communicable Disease Control Directorate (CDCD) of WA Health was later notified of the outbreak and undertook an advisory role, which included the formulation of an outbreak action plan that included the local PHU, the General Practitioners (GPs), ED clinicians and the independent IPCC.

1.2 METHODS

1.2.1 ENVIRONMENTAL AND INFECTION CONTROL INSPECTION

The independent IPCC conducted a risk assessment of infection prevention and control practices and processes at the abattoir. This assessment involved a walk-through of the facility observing the abattoir’s hand hygiene facilities and practices including maintenance of skin integrity, personal hygiene, selection and use personal protective equipment (PPE), environmental hygiene and laundering of uniforms. Recommendations were provided and a follow-up visit was conducted within five weeks to review progress with the implementation of the recommendations.

1.2.2 LABORATORY METHODS

Wound specimens for microbiological culture were collected from injured employees who presented at the ED of the local hospital or their GP. All MRSA isolates were referred to the ACCESS Typing and Research laboratory at Royal Perth Hospital. ST93-IV MRSA were identified using a combination of phenotypic and genotypic methods including mecA and nuc PCR, pulsed-field gel electrophoresis, multi-locus sequence typing, SCCmec typing, spa typing, PVL gene PCR and DNA microarray.

1.2.3 CASE FINDING

A retrospective analysis of the incidence rate of ST93-IV MRSA within the region prior to the outbreak identified only sporadic cases within the community. The baseline rate of ST93-IV MRSA within the local community was established from these results, which determined that this in fact was an outbreak.

A case definition was established as any person identified with community-acquired ST93-IV MRSA infection or colonisation that was epidemiologically linked to the abattoir. In
order to identify all ST93-IV MRSA cases, CDCD provided the PHU with a line-listing of all MRSA in the region from the ACCESS Typing and Research laboratory in the previous seven months. The PHU and the IPCC liaised with the managers of the abattoir to identify employees on the list. A short telephone interview with the identified staff members was conducted by the CDCD to obtain demographic information, their workplace practices, information regarding their infection including the site, their symptoms and any previous infections, their household members and discuss infection control measures and decolonisation treatment (Appendix 1). The PHU sent identified employees advisory letters and information about CA-MRSA infections, transmissions and decolonisation processes.

1.2.4 Containment Measures

The ACCESS typing laboratory continued to inform the CDCD and PHU of all new MRSA isolates from the region to ensure on-going monitoring of the outbreak.

A multi-modal approach was taken to contain the outbreak. The PHU contacted all ST93-IV MRSA cases to ensure that they had been seen by a GP or medical officer (MO) and infections were appropriately treated.

An outbreak advisory letter and relevant WA Health information to support recommendations were distributed by the PHU to all GPs and hospital MOs in the region. The recommendations by WA Health included the correct management of known CA-MRSA cases, decolonisation of cases and all of their household contacts following clearance of infection, clearance of infection before employees could work in the meat processing area and emphasis on obtaining specimens for culture of all people presenting to health services with skin and soft tissue infections. The managers at the abattoir were instructed to have a heightened awareness of skin infections occurring in employees and to report these to the PHU. The CDCD and the PHU liaised with the IPCC regarding recommendations for implementation at the abattoir.

1.3 Results

There were 22 ST93-IV MRSA cases epidemiologically linked to the abattoir in this outbreak; 15 abattoir employees and seven household contacts of infected abattoir employees. Of the fifteen cases employed at the abattoir, 12 worked on the slaughter floor and one was a maintenance officer, whilst the duties for two of the employees could not be established. There were three houses where cases shared accommodation, with some individuals moving between addresses.
The majority of cases (45%, n=10) had infections located on the arms and hands. Six cases had infections on the torso (axilla [3 cases], back, abdomen, and groin); four of these were household contacts. The remaining six cases had infections on the legs (n=4) and face (n=2). When recorded, boils and wound infections were the most common infection type. Four cases required incision and drainage of the abscess and treatment with IV antibiotics, with two of those cases requiring hospitalisation for seven days.

Retrospective investigations found sporadic cases of ST93-IV MRSA associated with the workers dating back to December 2012; however the increase of cases presenting to the ED occurred between April and June 2013 (Figure 1). The last case linked with the abattoir was in September 2013.

![Figure 1. Cases of ST93-IV CA-MRSA cases linked to the abattoir from Dec 2012 – Sept 2013](image)

The independent IPC positive findings and improvements implemented at either the initial or follow-up site visits are described in Table 1. Although the abattoir management was proactive in minimising the risk of infection, their efforts were hampered by limited knowledge and available initial support to the company. Additional recommendations were provided by the IPCC to address the re-use of soap and alcohol-based hand rub reusable cartridges, dispensing of adequate volume of alcohol-based hand rub and the daily restocking of empty paper towel dispensers by contract cleaners.

From follow-up interviews, all 15 cases and seven household contacts had decolonisation treatment. A letter and information were circulated by the PHU to GPs and ED clinicians again in August following the last two cases to remind them of the importance of obtaining specimens, management of positive cases, and to reassert the consistency of management across all health service sites.
Table 1. List of health and safety improvements implemented at the abattoir

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strict enforcement of hand hygiene and boot washing procedures</td>
</tr>
<tr>
<td>Wash facilities located at every entry/exit to meat processing area</td>
</tr>
<tr>
<td>Installation of hands-free alcohol-based hand rub dispensers</td>
</tr>
<tr>
<td>Hand Hygiene signage at all points of entry to amenity areas and facilities</td>
</tr>
<tr>
<td>Thermal disinfection of knives in accordance with CSIRO requirements</td>
</tr>
<tr>
<td>Staff room environmental surfaces and furniture cleaned and disinfected at</td>
</tr>
<tr>
<td>the end of each day</td>
</tr>
<tr>
<td>Increased consultation and monitoring of contract cleaners’ work performance</td>
</tr>
<tr>
<td>Access to water-resistant dressings in the event of skin and soft tissue</td>
</tr>
<tr>
<td>injury</td>
</tr>
<tr>
<td>All staff uniforms laundered at local commercial laundry</td>
</tr>
<tr>
<td>Labelling of individual staff lockers for storage of personal clothing</td>
</tr>
<tr>
<td>Staff changes of clothing prior to commencing work and leaving work.</td>
</tr>
</tbody>
</table>

1.4 DISCUSSION

This is the first report, to our knowledge, of a MRSA outbreak associated with abattoir workers in Australia involving a CA-MRSA strain. Whilst outbreaks of *Staphylococcus* species in abattoir workers have been long reported, previous outbreaks of MRSA have been livestock-associated (LA) strains, typically involving the strain ST398\(^\text{16}\). ST398 is the MRSA lineage most often associated with asymptomatic carriage in intensively reared food-producing animals, especially pigs\(^\text{16}\). Whilst the outbreak we have described occurred in a subset of the community linked to the local abattoir, it is unlikely that this outbreak was livestock-associated, as ST93-IV MRSA is the most frequently isolated CA-MRSA strain in Australia and not genetically related to the common LA-MRSA strain ST398. This outbreak should be regarded as an opportunistic outbreak of CA-MRSA amongst employees who often obtain cuts and abrasions in their workplace and spread to their household contacts.

By the very nature of the job, abattoir workers are exposed to a variety of pathogenic organisms including *Erysipelothrix rhusiopathiae, Bacillus anthracis, Coxiella burnetti,* and *Leptospira* as well as zoonotic Staphylococcal and Streptococcal sepsis\(^\text{17,18}\). Although common in the 1970s and 1980s, reports of recent outbreaks in abattoir workers are now infrequent, possibly due to increased occupational health and safety regulations.

The independent IPCC identified several risk factors that contributed to the outbreak, including the frequent cuts and abrasions to employees’ hands and forearms as the safety gloves provided impaired movement and were often not worn, a high proportion of transient workers shared accommodation, and workers socialised both during and outside of work hours. The IPCC noted that there was increasing anxiety created in the workplace and local community due to the lack of information available regarding the outbreak and
the lack of coordinated effort in the face of increasing cases with local GPs unfamiliar with meat processing work-related illnesses and injuries leading to potential misdiagnosis of infections. Further complicating the situation were the cost implications for employer and employees in relation to MRSA screening, treatment and decolonisation, and the need for work exclusion until the employee’s infection had resolved.

Although in WA it is not standard practice for an independent IPCC to be involved in an outbreak investigation, the timeliness of occupational health and safety measures instigated by the abattoir’s management on recommendation by the IPCC reduced the potential severity and length of the outbreak.

1.5 LIMITATIONS
The lack of co-ordination between the PHU and other health services involved was identified as a major issue at the beginning of the outbreak, and information on treatment and management of these infections was varied and inconsistent. A uniform action plan and communication strategy were developed to include all health care providers, enabling workers to obtain the correct information and ways to access treatment and appropriate follow up.

As some of these workers are recruited from overseas and English is their second language, effective communication efforts were difficult. Some workers were on casual or short-term contracts and were quite transient, so traceability of some cases was impossible.

1.6 CONCLUSION
This outbreak of ST93-IV MRSA infection in an abattoir highlights the importance of infection control and occupational health and safety procedures in preventing CA-MRSA infections in high-risk workplaces. Additionally, this outbreak identified a need for a co-ordinated approach for the distribution of information and management of decolonisation to prevent further transmission.
2. A NOROVIRUS OUTBREAK AT A HOTEL RESTAURANT

2.1 INTRODUCTION

Noroviruses (previously called Norwalk-like virus) are small, non-enveloped viruses containing a single positive-strand RNA genome, approximately 7.7kb in size, and are the most common causative agent for gastroenteritis. The common symptoms of a norovirus infection include nausea, diarrhoea, vomiting and abdominal cramps, headache, chills, low grade fever, muscle aches and tiredness. Incubation of norovirus is between 10 – 51 hours; onset of the illness is sudden with symptoms lasting between 24–60 hours. Although norovirus gastroenteritis is generally mild and of short duration, in some cases illness can be severe and sometimes fatal, especially among young children and the elderly. The treatment for norovirus gastroenteritis, like that for other diarrheal illnesses, is oral rehydration with fluids and electrolytes, if the patient is alert and able to drink, or with intravenous fluids, if vomiting and dehydration are severe. Norovirus is detectable in faeces and vomitus by RT-PCR or ELISA.

Norovirus can affect all ages and occur all year round, however outbreaks are more common during the colder seasons. Outbreaks often take places in environments which favor person-to-person spread, such as nursing homes, day-care centres or hospital wards. The Centers for Disease Control and Prevention (CDC) estimates that ~50% of all outbreaks of norovirus infection are linked to ill food service workers.

The virus is spread primarily through the faecal-oral route, however can also be spread through droplets of vomitus, contaminated fomites, person-to-person contact and environmental contamination. Norovirus can withstand a wide range of temperatures, from freezing to 60°C, and persist on environmental surfaces, in recreational and drinking water, and in a variety of food items, including raw oysters and fruits and vegetables, for a long period of time. Norovirus is highly contagious with a low infectious dose (approx. 18 – 1000 viral particles) required to cause illness.

It is possible that norovirus can also spread via food if handled by an ill person with poor hand hygiene. Barker et al found that fingers can both deposit and acquire norovirus when they come into contact with environmental surfaces, whilst Boxman et al demonstrated directly the presence of norovirus RNA on the hands of a food handler working in a restaurant associated with a recent outbreak. The most frequently reported factor associated with the involvement of the infected worker was bare hand contact with the food and failure to properly wash hands. Kuo et al found in an investigation of a
norovirus outbreak in Austria that the source of the norovirus was actually a staff member, who himself was asymptomatic, but his child was sick\(^2\); Asymptomatic infections can occur in approximately one third of infected persons\(^1\). Controlling outbreaks of norovirus pose major challenges\(^2\). Simple measures can be undertaken to prevent transmission of norovirus, such as cleaning contaminated surfaces, good hand hygiene, food handling and exclusion of symptomatic people. Changing gloves often and changing in between tasks decreases the chances of cross-contamination\(^1\). Those who have been ill with viral gastroenteritis should remain excluded from child care, school or work for a minimum of 48 hours after diarrhoea and/or vomiting stops\(^2,22,26\). Local health departments play a key role in educating restaurants and staffs in safe food handling procedures\(^1\). It was found that detergent-based cleaning with a cloth to produce a visibly clean surface consistently failed to eliminate NV contamination\(^2\). Bleach may be sufficient to inactivate the virus; Wiping benches with bleach (1 in 50 dilution of domestic bleach i.e. 1000 p.p.m.) is effective\(^2\). This study highlights the fact that detergent based cleaning without adequate disinfection carries the risk of increasing rather than reducing the risk of infection transmission\(^2\).

### 2.2 Background

OzFoodNet (OFN) at CDCD was notified by Dr Pippa Chidzey (PC) from the Kimberley Population Health Unit (KPHU) on 10 Tuesday December 2013 that six people had presented to a regional hospital emergency department (ED) with diarrhoea and/or vomiting (D&V) on Monday 9 December. Five of those had eaten at a local hotel restaurant and one was a staff member of the hotel.

PC asked if OFN would assist with the investigation; Barry Combs (BC) asked Anita Williams (AW) to lead the investigation. PC provided OFN with the initial line listing and contact details of the six people who had presented to the ED on Monday 9 December.

### 2.3 Methods

#### 2.3.1 Outbreak Team

An outbreak investigation team was formed in response to the notification of the cases. The outbreak investigation team included:

- Anita Williams (AW), OFN
- Dr Barry Combs (BC), OFN
- Emma Caitlin (EC), Environmental Health Officer (EHO) in a Kimberley shire
- Staff at the PathWest Enteric and Molecular Diagnostic laboratories
2.3.2 **SETTING**

The restaurant was situated within a hotel in a Kimberley town in northern WA. The restaurant was open for breakfast and dinner; however, all-day dining is available from the bar. The restaurant could seat 120 patrons. The restaurant did not normally take bookings.

2.3.3 **INTERVIEWS**

AW interviewed the five patrons (who had presented at the ED) of the hotel restaurant on 10 December using a hypothesis-generating questionnaire (Appendix 2). A further three contacts of the patrons were interviewed on the 10 December. On 13 December, another case of D&V who presented to the local ED after consuming food at the hotel restaurant on the 10 December was interviewed.

This questionnaire contained questions about their illness – the onset date and time of their symptoms, details of their symptoms, duration of illness and food/drink consumed at the hotel and other venues. Ill people were also asked if they used the toilet whilst at the hotel, and whether they had had contact with anyone experiencing gastroenteritis in the past four weeks.

2.3.4 **CASE DEFINITION**

A case was defined as a person who became ill with D&V within 48 hours of consuming a meal at the hotel restaurant from 8 – 11 December 2013. Of the 10 people interviewed, there were eight people who met the case definition. This case definition was derived in discussion with the OFN team after performing the first 6 interviews.

2.3.5 **LABORATORY TESTING**

Sample pots for faecal specimens were provided to all the cases who presented to the local ED to take home and return with specimens. However, samples were only submitted by three cases. These were sent to PathWest and tested for enteric pathogens including *Salmonella, Campylobacter, Shigella, norovirus, rotavirus, and adenovirus*.

2.3.6 **COMMUNICATION**

Constant communication with members of the outbreak team was kept through emails and telephone calls. A timeline of important outbreak events is listed in Table 2.
Table 2. Details of activity and communications by outbreak team for this investigation

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>What Happened</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/12/13</td>
<td>08:55 AM</td>
<td>PC of KPHU rang BC to notify OFN of potential outbreak</td>
</tr>
<tr>
<td></td>
<td>09:03 AM</td>
<td>BC emailed AW to ask to investigate</td>
</tr>
<tr>
<td></td>
<td>09:28 AM</td>
<td>PC emailed EC at local council to initiate environmental health investigation</td>
</tr>
<tr>
<td></td>
<td>10:00 AM</td>
<td>AW began telephone interviews of cases</td>
</tr>
<tr>
<td></td>
<td>10:35 AM</td>
<td>AW emailed EC to initiate contact between OFN and local council</td>
</tr>
<tr>
<td>11/12/13</td>
<td>ALL DAY</td>
<td>AW performed telephone interviews</td>
</tr>
<tr>
<td>12/12/13</td>
<td>ALL DAY</td>
<td>AW followed up cases to finalise length of illness</td>
</tr>
<tr>
<td></td>
<td>12:00 PM</td>
<td>AW rang PathWest to ascertain how many samples were submitted for testing</td>
</tr>
<tr>
<td></td>
<td>14:30 PM</td>
<td>PC emailed OFN of another case presenting to Derby ED</td>
</tr>
<tr>
<td>13/12/13</td>
<td>09:45 AM</td>
<td>AW performed telephone interview with case presenting previous day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EC from local council issued an improvement notice on hotel</td>
</tr>
<tr>
<td>17/12/13</td>
<td>12:00 PM</td>
<td>PathWest reported that all three samples had norovirus detected</td>
</tr>
</tbody>
</table>

2.4 RESULTS

2.4.1 EPIDEMIOLOGICAL INVESTIGATIONS

A total of 10 patrons and three staff were interviewed by the outbreak team in this investigation (Figure 2).

![Figure 2. Epicurve for onset of illness for patrons and staff at hotel restaurant](#)
Two of the 10 patrons interviewed did not present with D&V, however they did report nausea and a general feeling of being unwell (Table 3) and were subsequently determined not to be cases. Symptoms were self-reported, as per the questionnaire.

**Table 3.** List of symptoms experienced by patrons in this outbreak

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Cases [n = 8]</th>
<th>Non-cases [n = 2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nausea</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Abdominal pain and cramps</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Fever</td>
<td>6 (2 unsure)</td>
<td>1</td>
</tr>
<tr>
<td>Headache</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Lethargy/tiredness</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>8</td>
<td>--</td>
</tr>
<tr>
<td>Vomiting</td>
<td>8</td>
<td>--</td>
</tr>
<tr>
<td>Chills</td>
<td>4</td>
<td>--</td>
</tr>
</tbody>
</table>

A variety of meals were consumed by cases, with hot chips and the side salad in common across all the cases (Table 4). The two patrons who were not cases reported eating hot chips but not their side salads. Of the cases, five were male and three were female, with a median age of 31.5 years (range 21 – 59 years). Onset of illness in patrons was on 9 December and the median incubation period was 29 hours (range 24.5 – 43 hours). The median length of duration of diarrhoea was 27.5 hours and for vomiting was 4 hours. No patrons reported illness prior to attending the hotel or had contact with anyone who had gastroenteritis prior to visiting the hotel. The hotel does not take bookings for meals so other cases could not be identified. No statistical analysis was performed as only a small number of patrons was identified.

**Table 4.** Foods consumed at the hotel restaurant by patrons. Mains were served with salads

<table>
<thead>
<tr>
<th>Meal</th>
<th>ILL</th>
<th>NOT ILL</th>
<th>Meal</th>
<th>ILL</th>
<th>NOT ILL</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Fish and chips</em></td>
<td>3</td>
<td>2</td>
<td><em>Chicken parmigiana</em></td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td><em>Chicken burger with chips</em></td>
<td>2</td>
<td>--</td>
<td><em>Consumed any salad</em></td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td><em>Beef burger with chips</em></td>
<td>1</td>
<td>--</td>
<td><em>Tartare sauce</em></td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><em>Steak with chips</em></td>
<td>1</td>
<td>--</td>
<td><em>Aioli</em></td>
<td>--</td>
<td>2</td>
</tr>
</tbody>
</table>

### 2.4.2 Microbiological Investigations

All three faecal samples tested positive for norovirus by PCR and no other pathogens were detected.
2.4.3 Environmental Health Investigations

On 10 December 2013, the KPHU notified the EHO of the suspected outbreak. Under the Food Act 2008 (the Food Act), the EHO from the Kimberley Shire Council was the appropriate enforcement person and agency for the environmental health investigation. EC, an authorised officer under the Food Act, conducted an assessment at the hotel restaurant on 10 December, and found breaches to standard hygiene policies, including unclean benches and floors, inadequate signage regarding hand washing and no records of food handling training for staff.

On investigating the staff, EC discovered that one member of staff presented to the local ED on 6 and 7 December but still attended work on 8 December, and was subsequently ill in the hotel toilets that were also used by patrons. It was also revealed that on 9 December a further seven staff presented with gastroenteritis, including one member of staff which presented to the local ED.

Of those further seven staff one staff member was a kitchen hand and one staff member worked at the bar. Both staff members reported vomiting in the hotel toilets whilst at work. EC met with staff to discuss adequate hand washing and food handling techniques but only interviewed three staff members using the standardised questionnaire. All interviewed staff reported episodes of vomiting and diarrhoea.

The staff at the hotel consisted mainly of backpackers and overseas workers and, as such, the hotel had a high turnover rate of staff and no official records of adequate food handling training. An improvement notice was issued to the hotel on Friday 13 December by EC, along with a training kit for food handlers. EC also advised management on cleaning and sanitising and exclusion periods for ill staff. Training of the staff was discussed again with the hotel in early January 2014.

For this investigation, EC did not collect food samples as there was no food leftover from the implicated dates. Currently in WA there are no methods of detecting norovirus in non-human specimens. No food or environmental swabs were taken for investigation of other potential pathogens.

2.5 Discussion

The evidence obtained in this outbreak investigation suggests that patrons are likely to have become ill from food contaminated with norovirus. It was determined for the pathogen to be norovirus as the three samples submitted for laboratory analysis norovirus positive and the symptoms, duration of illness and incubation period among other patrons were norovirus-like.
Although it is possible for transmission to occur through exposure to contaminated environments, such as toilets, it was decided not to be the means of transmission in this outbreak as not all cases reported using the toilet at the restaurant and so foodborne illness to be most likely. There appears to have been person-to-person transmission among staff before transmission to the patrons. The staff that reported being ill at work indicated they were infectious while preparing food. As the onset dates for the staff preceded those of the patrons, the transmission was likely from the staff to patrons. Patrons who attended the hotel from 8 to 13 December are likely to have become ill from eating contaminated food such as salad, eaten by all cases and not eaten by two well patrons. The salad was a green salad, and any norovirus contamination would not have been inactivated prior to eating. However, staff members were ill in toilets and so patrons may have been infected via contaminated environmental surfaces. Many more patrons may have become ill, but as there were no booking lists this could not be established.

By issuing the hotel an improvement notice, the hotel was forced to clean the premises, minimising any environmental norovirus contamination. Educating the food handlers and hotel staff regarding possible control measures, hand hygiene and exclusion of ill staff prevents possible cases in the future. WA Health provides information for food handling premises in their Operational Directive "OD 0303/10: Guidelines for exclusion of people with enteric infections and their contacts from work, school and child-care settings"[29].

2.5.1 LIMITATIONS

The main limitation of this investigation was the small number of patrons able to be contacted, as there was no booking list, and the EHO only interviewed three of the seven ill staff. This investigation could be classified as a case-series as there were insufficient cases and controls to proceed with an analytical study, which may have more accurately determined the mechanism of transmission. Ultimately this investigation contains multiple co-factors and biases, such as potentially poor hand hygiene by patrons using the restaurant bathroom facilities, that could not be avoided.

At the time of this investigation, testing for norovirus in environmental swabs or food samples was not available. There was no left over food available for testing for other potential pathogens.

Whilst there was consistency in laboratory results from the three faecal samples submitted for analysis, these samples were collected from only three of the eight cases and did not include any of the ill staff members or non-case patrons.
2.6 CONCLUSION

Despite the fact that no specific vehicle being identified, the investigation provided an opportunity for education of the owners and staff of the hotel restaurant about appropriate food handling and the guidelines for exclusion of people with enteric infections and their contacts from work. This study emphasises the need for continual assessment of restaurants to ensure staff have adequate food safety training, and highlights the need for the development of testing capabilities of non-human samples for norovirus.

2.7 RECOMMENDATIONS

- On-going training for food handling staff at the hotel restaurant (current and future staff members)
- Ensuring ill staff stay away from work for 48 hours post cessation of gastrointestinal illness

3. REFERENCES


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27. Todd ECD, Greig JD, Bartleson CA, Michaels BS, Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 3. Factors Contributing to Outbreaks and Description of Outbreak Categories. J Food Protect. 2007; 70(9)2199-2217.


4. **APPENDICES**

**DEMOGRAPHICS**

<table>
<thead>
<tr>
<th>First Name</th>
<th>Last Name</th>
<th>Sex</th>
<th>DOB</th>
<th>Age</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Patient Address</th>
<th>County</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Email Address</th>
<th>Home Phone</th>
<th>Work Phone</th>
<th>Cell Phone</th>
</tr>
</thead>
</table>

**OCCUPATION**

It will help us to know about where you work and what you do there. This information is for our investigation only and will not affect your job in any way.

**Where do you work?**

If MEATWORKS, which area do you work?

- [ ]Processing
- [ ]Non-Processing
- [ ]Other

Do you get cuts from daily tasks?

- [ ]Yes
- [ ]No
- [ ]Unsure

Daily tasks:

If YES to cuts, do these sites get infected?

- [ ]Yes
- [ ]No
- [ ]Unsure

**HOUSEHOLD**

We would like to know some information about your household. This information will remain strictly confidential.

**How many people in your house?**

- [ ] ADULTS
- [ ] CHILDREN

Has anyone in your household had a similar infection?

- [ ]Yes
- [ ]No
- [ ]Unsure

If YES, who?

Has any of your friends or relatives had a similar infection?

- [ ]Yes
- [ ]No
- [ ]Unsure

If YES, who?

Did they attend the doctors and/or hospital for their infection?

- [ ]Yes
- [ ]No
- [ ]Unsure

If YES, where?

Have all the members of your household undergone decolonisation?

- [ ]Yes
- [ ]No
- [ ]Unsure

If NO, why not?

DECOLONISATION

Have you received a letter about decolonisation?

- [ ]Yes
- [ ]No
- [ ]Unsure

Have you seen a doctor about decolonisation?

- [ ]Yes
- [ ]No
- [ ]Unsure

Have you completed your decolonisation?

- [ ]Yes
- [ ]No
- [ ]Unsure

If NO, reason
The Department of Health is investigating gastroenteritis among patrons who attended the Hotel and hotel staff on Sunday 8 December 2013. Infectious gastroenteritis can be caused by bacteria, viruses and protozoa and transmitted from person to person, from animal to person or by food. (see link [www.public.health.wa.gov.au/2/597/2/gastroenteritis_fact_sheet.pm](http://www.public.health.wa.gov.au/2/597/2/gastroenteritis_fact_sheet.pm)). We would be grateful if you could answer some questions about food you ate at the Hotel and if you became ill afterwards.

“The investigation is conducted under the Health Act, 1911 and any identifying information you provide will be kept strictly confidential.”

**Note:** To help identify the cause of the outbreak, it is important that both WELL and ill people fill in this questionnaire.

**Instructions**

1) Save this document to your computer.
2) Fill in the questionnaire, regardless of whether or not you were ill as it is important to compare the food eaten by ill and not ill people.
3) Mark the appropriate Yes/No/Don’t know response by placing a X in the box.
4) Save the questionnaire containing your responses.
5) Please email the completed form back to ozfoodnetwa@health.wa.gov.au as an attachment.
6) If you have difficulty filling in the form using the check boxes, you can print off the form, fill it in by hand, scan the document, and email it back to us. Or post the completed form back to OzFoodNet WA, Communicable Disease Control Directorate, PO Box 8172, Perth Business Centre, WA, 6849.

**Personal Details**

Staff: Yes □ | Staff occupation
Patron: Yes □ | Date(s) and time of Hotel visit AM/PM
First Name: Last Name:
When did you arrive in the Kimberley (tourist)?
Contact phone number:
Age: Sex: Male / Female
Please indicate the Yes/No/Don’t know choices by marking the box “□” with a X

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Did you attend the Hotel on Sunday 8 December?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Part A – Recent Illness**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have you been unwell with gastroenteritis (diarrhoea, vomiting and/or abdominal cramps) in the four weeks before or on Sunday 8 December?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Yes fill in Question 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Have you been unwell with gastroenteritis (diarrhoea, vomiting and/or abdominal cramps) after the Sunday 8 December?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Yes fill in Question 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Did you have any of the following symptoms in the last four weeks? *(include date of onset and time of onset)*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
<th>Onset Date</th>
<th>Time of Onset (use 24 hour clock)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhoea (3 or more loose stools in 24hrs)</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Blood in stools</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Nausea</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Vomiting</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Abdominal pain/cramps</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Headaches</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Tiredness</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Chills</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Other symptoms</td>
<td></td>
<td></td>
<td></td>
<td>___ / ___ / _____</td>
<td></td>
</tr>
<tr>
<td>Please Specify</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. How long did your diarrhoea symptoms last? ___ day/s.

How long did your vomiting symptoms last? ___ day/s.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
<th>Specify</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Did you seek medical attention?</td>
<td></td>
<td></td>
<td></td>
<td>Name of doctor:</td>
</tr>
<tr>
<td>6. Did you provide a stool sample?</td>
<td></td>
<td></td>
<td></td>
<td>Where?</td>
</tr>
<tr>
<td>7. Were you hospitalised?</td>
<td></td>
<td></td>
<td></td>
<td>Number of days</td>
</tr>
<tr>
<td>8. Are you still having diarrhoea?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. Have you taken any medication given to you by the hospital or bought at chemist?
   If yes, specify?
   □  □  □

10. Has anyone from your family or friends been unwell with gastroenteritis (diarrhoea, vomiting and/or abdominal cramps) in the last four weeks?
    If Yes please specify name, contact details, symptoms and date of first symptom
    □  □  □

Consumption of food and beverages

We are interested in finding out what you ate and drank at the Hotel

<table>
<thead>
<tr>
<th>Entree</th>
<th>Main</th>
<th>Dessert</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What food was shared

Drinks

| 11. Do you have any special dietary requirements (e.g. vegetarian, gluten free.....)
   If yes, please specify what type |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. While at the Hotel on 8 December did you visit the toilet?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>□</td>
</tr>
</tbody>
</table>

| 13. Did you eat food at any other venues on Sunday 8 December or Monday 9 December?
   If yes to eating elsewhere specify place, time and food eaten |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>□</td>
</tr>
</tbody>
</table>

Thank you
Chapter 6

Teaching exercises
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1. PROLOGUE

1.1 CONTEXT

There are two teaching requirements in this course:

- prepare and conduct a case study for first year MAE students or other epidemiology training program, as part of the second year subject 'Issues in Applied Epidemiology'
- each student must prepare at least one (and participate in all) "lesson from the field" (LFF)

1.2 MY ROLE

1.2.1 ISSUES IN APPLIED EPIDEMIOLOGY

For the teaching assignment of "Issues in Applied Epidemiology" I worked with Tim Sloan-Gardiner to present a lesson on "Critical Appraisal of Scientific Literature" to the first-years during our 3rd course-block in March 2014. Tim and I created a power-point which discussed the basics and the why's of critical appraisal, as well as a document with instructions, examples and questions for the teaching session.

During the teaching session, Tim and I presented the overview to the first-years, after which we split the group into two groups and each took a group through the document of examples and questions.

1.2.2 LESSONS FROM THE FIELD

For my LFF I presented on "Sample Size and Power Calculations", creating an overview document on the why and how of sample size and power calculations, and three example exercises for participants to complete. On 16 July 2014 I discussed with the participants (the 2013 MAE cohort plus two from the 2014 cohort) my LFF via teleconference, any challenges they had in understanding the how-to of calculations and completing the example exercises.

1.3 LESSONS LEARNED

1.3.1 ISSUES IN APPLIED EPIDEMIOLOGY

In this exercise, I learnt that to obtain group consensus takes a lot of time and effort – Tim Sloan-Gardiner did an amazing job in organising this project, from the initial discussions of what we should do as a group to the first failed attempt of teaching videos to our final
teaching session to the first years. I also learnt that having a good partner is the key for success – Tim and I worked well together, as we both had the same vision for what we wanted to get across in our session and communicated well.

1.3.2 Lessons From the Field

Previous to my LFF, I knew the basics of sample size and power calculations as I used them in my ethics application for my epidemiological research project. However, in writing up my LFF I learnt the context of why, and that these calculations are estimations and not to be taken as gospel, as recruitment and attrition can be affected by a multitude of things. I also learnt that creating example questions is very hard and time consuming.

1.4 Acknowledgements

Katrina Knope, Tim Sloan-Gardiner, Courtney Lane, Dr Niki Foster and Hayley Roberts
2. CRITICAL APPRAISAL OF SCIENTIFIC LITERATURE

Anita Williams and Tim Sloan-Gardiner for the MAE Teaching Exercise, 3rd Course-block
March 2014

2.1 BACKGROUND

Critical appraisal is defined as the “application of rules of evidence to a study to assess the validity of the data, completeness of reporting, methods and procedures, conclusions, compliance with ethical standards, etc.”\(^1\). It is an important skill for a field epidemiologist to have and will be the subject of an assignment in the coming year.

Essentially, it is the process of systematically scrutinising research to judge the validity of the researchers’ findings and to assess the worth and relevance of the public health implications. Just because a paper is published in a peer reviewed journal, does not mean the findings are trustworthy or relevant.

There are many different resources available for critically appraising peer reviewed literature, and we will focus on the Critical Appraisal Skills Programme (CASP, www.casp-uk.net) critical appraisal framework.

2.2 OUTLINE

The training is proposed to occur via an interactive face-to-face teaching session. This session is expected to take approximately 40 minutes. Prior to the session, students will be given a peer reviewed paper and the CASP framework to read.

The first part of the session will cover some background on what critical appraisal is and why it is important, including where to find CASP resources.

The second part will involve a tutorial style session (split into groups) where students used the CASP framework to critically appraise the ‘pre-reading’. Due to the time allocation, we will be unable to appraise the paper with the entire framework. As we will be following on from the teaching session on Selection and Measurement Bias we will add to this by focussing on the framework questions that specifically look at potential sources of selection and measurement bias in the paper.

The last part will get the students to assess the validity of the papers findings given the potential sources of selection and measurement bias identified through the framework questions. Further readings/references will be provided.

We will do a wrap/quiz up at the end to test the learning objectives.
2.3 **AIM**
To provide an introduction into critically appraising peer reviewed literature using the CASP critical appraisal framework.

2.4 **LEARNING OBJECTIVES**
By the end of the video, students should be able to:
- describe what is critical appraisal;
- explain why critical appraisal is important;
- recognise the CASP critical appraisal framework;
- recognise where to look in a paper to answer the framework questions that specifically look at potential sources of selection and measurement bias; and
- appraise the value of a paper and assess any public health implications arising from it.

2.5 **LESSON TIMELINE**
1. 10 minutes presentation
2. 25 minutes group work
3. 10 minute whole group discussion

2.6 **REFERENCE**
3. TEACHING EXERCISE HAND-OUTS

**Group exercise guide for MAE teaching exercise**

Critically appraising a paper
CASP Guidelines

---

**Learning objectives**

After completing this exercise, including the associated presentation, students will have the skills and ability to:

- describe what is critical appraisal;
- explain why critical appraisal is important;
- recognise the CASP critical appraisal framework;
- recognised where to look in a paper to answer the framework questions that specifically look at potential sources of selection and measurement bias; and
- appraise the value of a paper and assess any public health implications arising from it.

Developing team work is a further objective
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Overview

Organisation of the exercise:
- Divide into 2 groups of 4-6 participants
- There will be roving facilitators to answer questions and keep you on track
- This session should take you approximately 20 minutes
- Once completed we will come back together as a whole group and discuss the exercise.
Scenario

You are in your workplace beavering away at your scholarly work when you supervisor approaches. They present you with a paper titled “Incidence and risk factors for acute respiratory illnesses and influenza virus infections in Australian travellers to Asia” by Irani Ratnam.

Your supervisor explains that the Minister has gotten wind of this paper and is concerned about the implications for travel to Asia, given the sensitive political situation with Indonesia at the moment.

You are asked to read the paper and determine if the findings in the paper are valid. Specifically, your supervisor particularly wants you to focus on any potential biases in the paper. You have 20 minutes to report back to your supervisor as they have to go to a briefing with the Minister.

You have read the paper, and decide you need a framework with which to critically appraise the paper in order to report back to your supervisor. You remember being taught about the CASP framework during your MAE course block and decide to use that.

Group work

In your group, answer the following CASP framework questions specifically relating to potential biases:
**Question 1**

In broad terms, **what is the study about?**

For example, is it about the natural history of a disease, magnitude of a problem, cause-effect relationship, or evaluation?

What is the paper about?

**Our primary objectives were to (i) estimate the overall incidence density of ARIs (ii) estimate the incidence density of confirmed influenza virus infections in Australian travellers to Asia and (iii) identify the risk factors associated with ARIs.**

Where in the paper would you look to answer this question?

**2. Objectives**

What are they trying to do, descriptive epidemiology of an outbreak, determine risk factors, evaluate something, literature review, establish cause-effect relationships?

**Determine incidence and risk factors**

---

**Question 2**

What is the **study type**? Is this study type appropriate to answer the research question/s? Why? Is there an alternative study type that is ideal for addressing the research questions/objectives?

Where in the paper would you look to answer this question?

**3. Study Design**

What study type did they conduct? (Cohort, Case-Control, review, qualitative research, etc) Did they use the right one?

**Prospective cohort study over 3.5 years**

Already have a defined population/cohort and selection is based on exposure (travel to Asia) and age (over 16) and duration of stay overseas (minimum 7 days).
Question 3

Who constitutes the study population ('study base' for a case control study)

Consider various levels in the process of selecting the study population, e.g. reference population, source population, sampling frame and sampling methods. Who constitutes the control group (if relevant)

Where in the paper would you look to answer this question?

3. Study Design

Who/what is the population being studied? Any potential selection biases?

**Australian travellers over 16 years of age intending to travel to countries within Asia only between August 2007 and January 2010 who attended one of three travel clinics – Royal Melbourne Hospital, The Travel Doctor/Travellers Medication and Vaccination Centre and Monash Medical Centre.**

Travellers over the age of 16 years and intending to travel to countries within Asia (only) for a minimum duration of 7 days were eligible to participate.

**Potential biases**

- Selection bias: Those attending travel clinics more likely to be health conscious (health seeking behaviours); How many people travelling to Asia actually visits a travel clinic? What about those who visit GP consultations?
- There is a belief that TMVC etc only push the flu vaccine to make more money (?). Also only looked at Melbourne travel clinics yet refer to results being for all of Australia. What about WA/NT with more travellers to Bali?
- Cost of consultation – TMVC is not cheap!
- Locations of clinics – two in CBD, one in SE Suburbs; two within hospitals
• Blood samples taken pre and post travel – potential for non-participation due to needle aversion (only 68.58% of eligible travellers agreed to participate)
• Length of stay overseas – potentially missing those who went for shorter period?
• Risk of lost-to-follow-up

Question 4
What are the outcome factors? Have operational definitions been provided? (use appropriate terms such as: ‘validity’, ‘reproducibility’, ‘blinding of observers’, ‘quality control’)?
What is an “outcome factor”?

The “dependant variable” or “response variable” – the outcome being studied

What are the outcome factors? Have operational definitions been provided?

The development of ARIIs within 72hrs of return from trip

Where in the paper would you look to answer this question?

3. Study Design, specifically 3.2 and 3.3

Look for operation/case definitions, is there potential for selection bias (e.g. misclassification of cases and controls/ill and not ill).
**Inclusion Criteria**

ARIs defined as illness episodes involving the presence of at least two of:

- Fever
- Sore-throat,
- Headache,
- Cough,
- Coryza,
- Myalgia

With at least one being a respiratory symptom (cough, coryza, and sore-throat) up to 72 hours after return to Australia.

ILI defined according to CDC criteria as fever plus either cough or sore throat – validated criteria

Confirmed influenza virus infection defined as seroconversion to influenza A/B and a clinically compatible illness consistent with ARI/ILI and/or a positive RT/PCT for Influenza A/B – validated testing

Positive PCR for respiratory virus from swab sample

**Exclusion criteria**

Travellers who reported already suffering from an ARI at the time of departure from Australia were not considered as ARIs related to travel.

**Potential biases**

Doesn’t take into account those who were exposed on planes/transit who developed ARI/ILI whilst on holiday

Well-defined criteria so low chance of misclassification. Broad case definition so good capture.

Table 1 lists ‘recent travel’ as a variable, which is clarified in the paper as recent international travel.

This would be a given, seeing as to be recruited you would have to have been travelling.
Question 5

What are the study factors? Have operational definitions been provided? (use appropriate terms such as: 'validity', 'reproducibility', ‘blinding of observers’, 'quality control')?

What is “study factor”?

The independent variable is also known as a “exposure variable" or “risk factor"

Where in the paper would you look to answer this question?

3. Study design, 4. Statistical Analysis and 5. Results

Have the operational definitions been provided?

Yes, see table 1 “variable”

What are the potential biases in the study factors?

Interview conducted with validated pre- and post-travel questionnaires so good internal validity. No mention if interviewers were trained or blinded to study aims so potential bias could be introduced.

Blood samples taken pre- and post- travel with testing carried out using validated methods. The methods only list some of the pathogens that can cause ARI/ILI that were tested for would have been good to have a complete list. What about pathogens not tested for? (e.g. bocavirus, coronaviruses, enteroviruses, metapneumovirus, avian influenza, rhinoviruses, respiratory syncytial viruses, and non viral pathogens)

Samples taken up to 8 days AFTER return to Australia (3 days for phone call then 3-5 days for sample to be taken) – capability of actually detecting virus?! Red book says up to 5 days of shedding after
ONSET of symptoms... The sensitivity of this study design is appalling.

Unable to detect virus of illness for those who were ill whilst away (excepting influenza seroconversion) – 109 travellers experienced at least one illness whilst away/on return. What about illness acquired in-flight as opposed to in-country?

Conducted regression analysis (Cox’s proportional hazards regression) which controls for cofounders and duration of travel. Appeared to look at age in 10 year age groups, but not well explained in paper. Would expect to see more younger males travelling to countries within Asia.

Mentions that country is a “time-dependent covariates”? Short-term travel is defined as less than 30 days in the results but not explained in the methods (post hoc definition?)

Why would the baseline be Australia? If the recruitment is based on those visiting travel clinics with the intention of travelling to countries within Asia, how would you then have people only travelling within Australia and could these be a large enough population for the model?

Question 6

Would you agree with how the study was designed, the population chosen etc? Why/Why not? Would you have performed the study in the same way? What would you have changed? Comments regarding results/findings/discussion/conclusions made?

In order to study what they wanted and easily recruit a study population the design was fine, however there are a few limitation of the design and population chosen and these are not discussed in the paper.
Additionally it should be noted that the work was supported by Sanofi-Pasteur, a vaccine company. Who would potentially make money from a finding recommending the use of more vaccines/antivirals for travellers...

The paper claims that they demonstrate that influenza still remains the most frequent vaccine-preventable infection in travellers to Asia. The study only contained 387 people with completed demographic and serological data, of which 4 (1%) were positive for influenza. Not sure they can make this claim seeing as they didn’t test for other vaccine-preventable diseases (i.e. measles).

“The occurrence of influenza in one traveller vaccinated pre-travel may have been to mismatch in strains or vaccine failure” what if you were positive for an influenza strain not covered by the current vaccine? The effectiveness of the vaccine? Pushes the idea of travellers having access to antivirals – what about resistant strains?

Only tested 29 for ARI PCR and only found picornavirus – usefulness of these results? Should this have even been included in the study?

Only uses clinics in Melbourne – what about other jurisdictions?
4. CRITICAL APPRAISAL POWERPOINT

Critical appraisal

Anita Williams and Tim Sloan-Gardner

But it was published in Science...

Evidence of a Floraform Human
Lobooth Stress Cell Line
New Cell Line, Defined From
New Cell Line, Defined From

P.S. You will have an exam on this!

Outline
- Overview of critical appraisal
- Resources for critical appraisal
- Group work
- Discuss findings

What is critical appraisal
- “application of rules of evidence to a study to assess the validity of the data, completeness of reporting, methods and procedures, conclusions, compliance with ethical standards, etc.”

But what is it really?
- systematically scrutinise research
- judge validity of findings
- assess worth and relevance

Why is it important?
Critical appraisal is important because it:
- allows you to identify the strengths and weaknesses of a piece of research
- develops an improved understanding of the research methodology used to conduct the research
- allows you to relate the published research to your local situation
- enables you to identify any bias in the research

Resources for Critical Appraisal
- http://www.casp-uk.net
  - CASP checklist
- http://www.strobe-statement.org
  - STROBE
  - Available for different types of study methodologies
- Other resources
  - Youtube
  - University webpages - Library
  - Published literature - Nature

Critical Appraisal Framework
- A series of questions (n=13) that allow you to critically appraise a paper in a transparent and repeatable way.
- The framework is provided in your handouts.

Group Work

Feedback of Findings

Your supervisor is at your desk...
- Were there potential sources of bias?
- What were the potential limitations?
- What do you consider to be the overall value (or valid contributions) of this study?
- What are the implications for public health practice and/or for further research?
5. LESSONS FROM THE FIELD: POWER AND SAMPLE SIZE CALCULATIONS

5.1 WHAT ARE “POWER” AND “SAMPLE SIZE”?

5.1.1 POWER CALCULATIONS

Power might sound like something you imagine the coach of an AFL team calculating for the output of players from the game stats, or the engineers at Red Bull looking at the output of a new Formula One car, but for research studies, calculating the power is important for determining the probability of whether the study will detect an association of a particular size if it truly exists in the general population.

The power of a study is the “chance of getting a significant result when some effect is really present” or the probability that the null hypothesis is rejected, if a specific alternative hypothesis is true. If you choose a power close to 100% means that there is very little risk that we shall miss a truly existing difference. A power of 65% means there is a 35% risk that our study will fail to find a truly existing association between exposure and outcome.

The power of any statistic is dependent upon several factors:

- The alpha (α) level you’ve established for the test – that is, the chance you’re willing to accept of making a type 1 error
- The actual magnitude of the effect in the population, relative to the amount of noise in the data
- The size of the sample

The power of a study is one minus the probability of a type-II error – saying there is no association when one truly exists (denoted by β). It is important to note the following things:

- For all statistical tests, power always increases as the sample size increases, if other things (such as alpha level and effect size) are held constant.
  - Very small samples very seldom produce significant results unless the effect size is very large.
  - Conversely, extremely large samples are almost always significant unless the effect size is near zero.
- For all statistical tests, power always increases as the effect size increases, if other things (such as alpha level and sample size) are held constant.
For very large effect sizes, the power approaches 100 percent. For very small effect sizes, you might think the power of the test would approach zero, but it does not go down all the way to zero; it is actually the alpha level of the test. Keep in mind that the alpha level of the test is probability of the test producing a significant result when no effect is truly present.

For all statistical tests, sample size and effect size are inversely related, if other things (such as alpha level and power) are held constant.

Small effects can be detected only with large samples; large effects can often be detected with small samples.

5.1.2 Sample Size

When designing a study, one of the first questions is “how many people will I need in my study?” and that is followed by a second question: “what for?” - The answer to the second question influences the answer to the first. Calculating a sample size is dependent upon what kind of study you are performing and how you plan to analyse your results. Whilst for statisticians, an n of greater that 30 is usually sufficient for the Central Limit Theorem to hold, this may be unrelated to the objective of detecting a biologically significant effect.

5.2 Why calculate?

Too often studies are carried out, with large amounts of money, time and other resources invested into the project, only find that from the beginning there were too few subjects to obtain meaningful results. Whilst some may say that “bigger is better”, in reality logistical and financial considerations constrict the size of a study; however, if the size is too small, an association between exposure and outcome may be missed due to statistical insignificance. Ideally, a study should be large enough to have a high probability (power) of detecting any associations if any should exist. Human research and ethics committees now require sample size and power calculations before giving approval; the size of a sample must be sufficient to accomplish the purpose of the project without being larger than necessary.

5.3 How do we calculate?

5.3.1 Power

Power calculations are a crucial part of the design of any research project. There is no set rule as to how much power a study should have, but in general most people would probably want a minimum of 80% power and many would aim for 90%. You do not want your study to be underpowered (with a high risk of missing real effects) or overpowered (larger, costlier, and more time-consuming than necessary). You need to provide a
power/sample-size analysis for any research proposal you submit for funding or any protocol you submit to a review board for approval - as long as you can justify why you are using this power, e.g. prevalence or limited resources, then the ethics committee will be satisfied. You can also calculate the power of a study after you have performed it to show that the sample size used was sufficient.

5.3.2 SAMPLE SIZE

The first step in calculating a sample size is to determine what kind of study you are going to perform.

Molutusky discusses three approaches to choosing a sample size for your study

1. Ad hoc
2. Conventional
3. Adaptive trials

If you take the ad hoc approach – collect some samples and analyse some data, then the p value and CIs cannot be interpreted; if the null hypothesis is true then chance of obtaining a statistically significant result is greater than 5%.

Adaptive trials analyse the data in the midst of the study to determine further actions – this approach is often performed in large clinical trials. However, in this exercise, we are going to remain conventional.

For all sample size calculations, the following information is needed:

- The null hypothesis – what you are trying to determine
- The type of study you are performing
- Required level of statistical significance of the ability to detect a difference – the power
- Acceptable error, or chance of missing a real effect – the alpha (α)
- Magnitude of the effect under investigation – effect size
- Amount of disease in the population – baseline probability
- Relative size of the groups being compared

When calculating a sample size, it is always safer to round upwards. It is important to remember that these are estimates of what is required, and life gets in the way. Typical α's and β's chosen for power calculations are 0.05 (two tailed) and 0.80 respectively. Sometimes you will not know the exact figures required when calculating, and that is where an educated guess based on previous information is necessary or the smallest sample that is of any clinical interest needs to be defined.
It is important to note that different calculators use different equations and ultimately this is an estimate of the size required; it is not gospel. By calculating the sample size required, it answers the question "If I use n subjects, what information can I learn?" and might show that it may just be impossible to determine what you are looking for.7

5.3.2.1 Two ways to do things
1) You could be old-school and perform the calculations by hand; the formula differs depending on the type of study you are going to perform. The World Health Organisation (WHO) has written up a "cookbook" for determining sample size in health studies (Lwanga and Lemeshow, 1991), and Kasiulevičius, Šapoka, and Filipavičiūte have also written a great article on calculating size for each of the different study types.5

2) Or you could use a calculator. There are many programs out there that calculate sample size – it is just a matter of choosing the appropriate one. EpiInfo has one, as does OpenEpi.com, and there are a multitude of other websites that can perform this task (see statpages.org). Or, you could download a program, such as "Power and Sample Size" (see "helpful resources").

5.4 Things to be mindful of...

5.4.1 This lovely table

Table 1. Possible outcomes of an epidemiological study1,2

<table>
<thead>
<tr>
<th>your conclusion (based on your sample)</th>
<th>the truth (based on entire population)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No association</td>
<td>Association</td>
</tr>
<tr>
<td>No Association</td>
<td>Correct</td>
<td>Type-II error (probability = β)</td>
</tr>
<tr>
<td>Association</td>
<td>Type-I error (probability = α)</td>
<td>Correct</td>
</tr>
</tbody>
</table>

5.4.2 Cluster and Multi-stage sampling

Cluster or multi-stage sampling methods require a larger sample size to achieve the same precision, to take into account any affect the structure or design of the study may have on the accuracy of the results.10

5.4.3 Attrition

Not everyone who says they will participate will participate. Or they may withdraw halfway through the project. It would be a shame if this occurred and subsequently the power of your study became too low to identify statistical significance. Therefore, it is wise to oversample by 10 – 20% of the computed numbers, depending on anticipated rate of attrition.10
5.5 REFERENCES FOR LFF


2. Pezzullo J. Biostatistics for Dummies. For Dummies; 2013.

3. STAT507 – Epidemiological Research Methods, Lesson 9.7 - Sample Size and Power for Epidemiologic Studies, Penn State University: https://onlinecourses.science.psu.edu/stat507/node/64 (accessed 30/06/14)


5.6 OTHER USEFUL RESOURCES


PS - Power and Sample Size calculator
http://biostat.mc.vanderbilt.edu/wiki/Main/PowerSampleSize

http://statpages.org

http://powerandsamplesize.com/
6. LFF QUESTIONS: POWER AND SAMPLE SIZE CALCULATIONS

6.1 WHAT YOU’LL NEED

A computer with EpiInfo, PS software or internet access – openepi.com

6.2 EXAMPLE 1 – DESCRIPTIVE STUDY SAMPLE SIZE

You want to determine the prevalence of asymptomatic *Clostridium difficile* carriage in nursing home residents. The organisation you are working with has 600 residents in their facilities. You have performed a literature review and determined that the mean asymptomatic carriage rate of *C. difficile* in nursing homes from other studies is around 17%. You will be performing all your own laboratory work.

1. What would the sample size be at the power of
   a. 80% = 81
   b. 95% = 122
   c. 99% = 237

2. Which would you choose and why? What would determine the reasoning behind you choosing a smaller/larger study?

I chose the 95% power for this study for a few reasons – 95% is more ethically defensible than 80%. I was capable of taking over 100 samples and the need to perform within 24hrs is important. Approx. 25% of residents will open their bowels in (half of 50%) = 150, so 99% is unattainable and unnecessary.

The main point of this question was that sample size calculations are an estimate.

6.3 EXAMPLE 2 – COHORT STUDY POWER CALCULATION

You have conducted a follow-up cohort study for an outbreak of *S. enteritidis* that occurred one year ago in a village of 9,004 inhabitants. The cause was traditional cream cakes, all made in the same baker's shop to celebrate Saint John's Eve. A total of 1243 persons were affected; about 40% were Torroella residents, 40% from other villages of the same county, and 20% visitors. Questionnaires were sent to 1878 potential participants – 677 had experienced *S. enteritidis* gastroenteritis, and 1201 had not. 267 exposed and 330 non-exposed returned the questionnaires. After 12-months, dyspepsia had appeared in 46 of 267 exposed participants and 11 of 330 controls. Similarly, at 12-months, IBS had appeared in 31 of 266 exposed participants and in 5 of 333 controls.
For each outcome answer these questions:

1. What was the risk ratio (with 95% CI) detected?

<table>
<thead>
<tr>
<th>Dyspepsia</th>
<th>Outcome</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>Yes</td>
<td>46</td>
<td>221</td>
<td>267</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>11</td>
<td>319</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>57</td>
<td>540</td>
<td>597</td>
</tr>
</tbody>
</table>

**Risk Ratio:** 5.2  
**CI:** 2.7 - 9.8

<table>
<thead>
<tr>
<th>IBS</th>
<th>Outcome</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>Yes</td>
<td>31</td>
<td>235</td>
<td>266</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>5</td>
<td>328</td>
<td>333</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36</td>
<td>563</td>
<td>599</td>
</tr>
</tbody>
</table>

**Risk Ratio:** 7.8  
**CI:** 3.1 - 19.8

2. What was the power of your study?

Exposed: Dyspepsia = 17.23%, IBS = 11.65%

Unexposed: Dyspepsia = 3.33%, IBS = 1.5%

3. Is this sufficient to say *S. enteritidis* gastroenteritis could lead to post-infectious dyspepsia/IBS? Why/why not?

Based straight off the above figures, it could be possible to state that *S. enteritidis* could lead to dyspepsia and IBS, however there are several confounding factors and biases in the study which should be addressed before drawing this conclusion.

### 6.4 Example 3 – Case Control Study

You want to conduct an experiment to determine if singing happy birthday before consuming cake makes it taste better. You want two equal groups, randomly assigned to each group – singing (case) or no singing (control).

1. How many cases and controls do you need assuming your study will have 80% power, you want to detect an odds ratio of 2.0 or greater, you want equal number of cases and controls (r=1) and the proportion of happiness in the control group is 20%?

173 cases and 173 controls = 346 participants

2. What power would your study have if you were limited to 100 people total (cases + controls), you had equal ratio of cases and controls, and the odds ratio for more likely to enjoy cake was 6? (You will need to then work backwards for this: figure out the percentages of exposure in each group and then use this to calculate the power)

50 cases and 50 controls, with 60% of cases and 20% of controls enjoying cake, with a power of 99%
6.5 REFERENCES

Descriptive study: My MAE epidemiological project “Asymptomatic gastrointestinal carriage of C. difficile in aged care facility residents”
