Applied Epidemiology in Aboriginal and Torres Strait Islander Health

A thesis submitted for the degree of Master of Philosophy in Applied Epidemiology (MPhil Appl Epid) at the Australian National University

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Declaration of work

This thesis is comprised of multiple discrete projects that were undertaken collaboratively with multiple stakeholders and the author acknowledges the contributions made by each of the stakeholders involved in the projects. Taken as a whole document, the author certifies 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 author’s best knowledge, this thesis does not contain material previously published by another person, except where a reference is made in the text. The author acknowledges that copyright of published works contained within this thesis resides with the copyright holders(s) of those works.

Anna-Lena Arnold

20/01/2016
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Abstract

My placement for the Master of Philosophy in Applied Epidemiology (MAE) degree was with the Evidence and Evaluation section, within the Indigenous Health Division, Australian Government Department of Health. In this thesis, I present projects undertaken which fulfil the requirements of the MAE program.

Data analysis project: The Northern Territory Aboriginal Health Key Performance Indicators (NT AHKPIs) are a collection of key performance indicators that measure primary health care (PHC) performance. I conducted a study to explore how PHC service X was performing when compared with other PHC services in very remote areas and all NT PHC services, based on NT AHKPI performance. Analysis showed an overall improvement at PHC service X from 2010 to 2014, but similar to other PHC services located in very remote regions and to the NT overall, there remains an opportunity for improvement in the areas of antenatal care, child health outcomes, blood glucose levels for type 2 diabetics, blood pressure results and adult health checks. Please note - the NT AHKPIs are not currently in the public domain, this chapter is therefore a closed chapter, and is not presented in this thesis.

Evaluation project: I evaluated the NT AHKPIs to assess the extent to which the NT AHKPIs are addressing their intended goals and to determine whether they were being used for other purposes; my approach to the evaluation was utilisation focused. Preliminary findings show that the KPIs are useful to inform service planning and continuous quality improvement, but there is room for improvement. Findings will be reported back to the NT AHKPI steering committee to inform ongoing strengthening of the NT AHKPI system.

Epidemiological study: Anaemia in Aboriginal and Torres Strait Islander children in the NT is a public health problem. I undertook a study to describe the application of best practice guidelines for screening and management of children aged 6 months to 3 years with anaemia in the NT. Findings show that of 5,543 children, 63% were screened for anaemia. The prevalence of anaemia was 40% - a ‘severe’ public health problem as defined by the World Health Organisation (WHO). A very low proportion of anaemic children were recorded as treated according to best practice guidelines, however, our findings are subject to multiple potential biases and these findings need to be validated.
Outbreak investigation: I was a member of the Communicable Disease Network Australia team that investigated an unusual cluster of *Ralstonia* bacteraemia from 1 April to 26 June 2014 in three states in Australia. The objectives of this investigation were to assess the possibility of a causal association between the administration of propofol and *Ralstonia* bacteraemia, and to identify sources of the infections. The propofol solution passed all sterility and contamination tests, but 18% of the flip-off caps and external surfaces of the rubber stoppers were contaminated with a variety of bacterial species including *R. mannitolylitica*. These isolates were genetically indistinguishable from three out of eight isolates from patients with *R. mannitolylitica* bacteraemia. Findings from this study highlighted the need for proper aseptic techniques when administering intravenous injections.

I spent ten weeks in Sierra Leone supporting the WHO’s response to the Ebola virus disease outbreak (EVD). I summarise my role and responsibilities in the outbreak, including a description of our investigation of a cluster of cases with EVD.
"Public health looks at illness and other risk factors in aggregate populations and comes up with wholesale solutions... Its philosophical base is social justice and its scientific base is epidemiology." - Bill Foege
Overview
My field placement for the Master of Philosophy in Applied Epidemiology (MAE) commenced on 17 February 2014, in the Evidence and Evaluation Section, Systems Effectiveness Branch of the Indigenous Health Division (IHD) at the Australian Commonwealth Department of Health. My field supervisor was Rachel Meyer and my academic supervisors were Associate Professor Mahomed Patel and Dr Emily Fearnley.

During this time I worked on three major projects and a range of other activities relevant to Aboriginal and Torres Strait Islander health and primary health care (PHC) in the Northern Territory (NT). Investigating acute public health problems is not part of the work of the Evidence and Evaluation section, so in addition to the projects relevant to Aboriginal and Torres Strait Islander health, I also had the opportunity to work on three different outbreak investigations outside of the IHD. These projects included an investigation into an unusual cluster of Ralstonia bacteremia in three states in Australia; assisting with a multijurisdictional outbreak investigation into cases of hepatitis A; and working with staff of the World Health Organization (WHO) in their response to the Ebola Virus Disease (EVD) outbreak in Sierra Leone in West Africa.

This introductory chapter briefly describes my field placement, how my projects and activities meet the MAE course requirements and the impacts and potential impacts of these projects on public health.

Field placement – Evidence and Evaluation section, Indigenous Health Division
The Evidence and Evaluation section is responsible for the monitoring and evaluation of Indigenous Health programs managed or coordinated by the IHD. The aims of the section are to produce timely, accurate and meaningful information on program implementation, impacts and outcomes to inform policy and practice and improve the health outcomes of Aboriginal and Torres Strait Islanders.

Summary of core MAE activities
See also Table 1 on page 1-8.
Analysis of public health data [Closed chapter]
The Northern Territory Aboriginal Health Key Performance Indicators (NT AHKPIs) are a set of indicators designed to measure performance of PHC services in the NT. I conducted a study to explore how one PHC service was performing when compared with performance of other PHC services in very remote areas and all NT PHC services, based on data from the NT AHKPIs [Chapter 2].

Public health impact
This analysis was requested by the First Assistant Secretary of the IHD in response to the possibility of PHC service X being transitioned from a Northern Territory Department of Health (NT DoH) managed service to an Aboriginal Community Controlled Health Organisation (ACCHO). This analysis highlighted that similar to the NT overall and for all other services located in very remote regions of the NT, there remain opportunities for improvement. Identifying an area of need is the first step in being able to bring about actions. Our findings were reported back to the First Assistant Secretary, although PHC service X has not yet been transitioned from an NT DoH managed service to an ACCHO service.

Evaluation of a health information system
I evaluated the NT AHKPIs to assess whether the indicators were addressing their intended goals, whether they were being used for other purposes and how the system could be improved for greater usefulness. My approach to the evaluation was utilisation focused [Chapter 3].

Potential public health impact
Consistent with the utilisation focused approach, a report on the findings and recommendations will be developed in collaboration with stakeholders to continue strengthening and developing the KPIs and the health outcomes of Aboriginal and Torres Strait Islanders. A summary of key findings will also be distributed to all who participated in the evaluation.

Conduct and interpret an epidemiological study
Anaemia in Aboriginal and Torres Strait Islander children in the NT is a severe public health problem. I undertook a study to assess the extent to which best practice guidelines recommended by the Central Australian Rural Practitioner’s Association
(CARPA) were being implemented for screening and management of children aged 6 months to 3 years with anaemia in the NT [Chapter 4].

This study showed that the prevalence of anaemia among children aged 6 months to 3 years attending NT DoH services between 2008 and 2013 is a ‘severe’ public health problem, as defined by WHO. It also provided evidence that a high proportion of anaemic children are not being treated according to the recommended CARPA guidelines. However, these latter findings need to be validated.

**Potential public health impact**
These findings will be disseminated to PHC clinic staff and presented at fora such as the annual CQI anaemia Collaboration, and the Annual Practical Paediatrics conference, to convince decision-makers and clinicians to change practise as a high priority.

**Field investigation of a public health problem (outbreak investigation)**
I participated in three field investigations of an acute public health problem. I was a member of the Communicable Disease Network Australia (CDNA) team that investigated an unusual cluster of *Ralstonia* bacteraemia from 1 April to 26 June 2014 in three states in Australia [Chapter 5.1].

This investigation highlighted the importance of strict aseptic techniques and the need for clearer instructions on the product information of medications, and ongoing continuing education for health professionals. This investigation also identified the need for guidelines on how to respond to multijurisdictional outbreaks of infectious diseases that are not notifiable in Australia.

Based on our findings, The Therapeutic Goods Association (TGA) posted a reminder on their website for all health professionals in Australia on the importance of using aseptic techniques when preparing and administering intravenous medications, with a particular focus on the need to swab the rubber stopper of any vial with a suitable disinfectant prior to drawing up sterile solutions.
I spent ten weeks in Sierra Leone participating in WHO’s response to the EVD outbreak. I led field investigations in three villages to identify contacts to place under quarantine, and supervised overall surveillance activities while responding to the needs of people under quarantine [Chapter 5.2].

No secondary transmission occurred in two of the three clusters or from the secret burial cluster that we investigated and advised on control measures. Although the international community was slow to respond to this outbreak in West Africa, the delayed multinational response efforts succeeded in controlling the outbreak. This response led to building up the skills for many of the local staff participating in the outbreak response and to rebuilding Sierra Leone’s health system. Sierra Leone currently (December 2015) remains EVD transmission free, but many organisations like WHO remain while the country maintains heightened surveillance and continues to strengthen surveillance systems, and to ensure the country is prepared to respond should EVD re-emerge. In addition to this, WHO are now starting to focus on addressing other public health issues, such as the very high rates of maternal and child deaths.

I shared my experience working in Sierra Leone with the IHD (my field placement) through a seminar presentation on EVD, how it is transmitted, a summary of the EVD outbreak in West Africa, my involvement in contributions to the response efforts, the challenges encountered by the local communities, health workers and multinational agencies, and particularly highlighting the importance of community engagement. It was discussed how we face similar challenges in Australia for remaining sensitive to cultural traditions, fear, misperceptions and lack of trust of Aboriginal and Torres Strait Islanders. Community engagement is integral to the success of any Aboriginal and Torres Strait Islander project or health program.

I also assisted OzFoodNet with a multijurisdictional outbreak investigation into 19 cases of hepatitis A linked to the consumption of Brand A frozen mixed berries from China. I assisted with recruiting and interviewing controls for the case-control study [Chapter 5.3 - Appendix].
Critical review of scientific literature and write a scientific manuscript for a peer-reviewed journal
As part of our investigation into the unusual cluster of cases of *Ralstonia* bacteraemia, I conducted a focused literature review to assess the level of contamination that could be expected in a vial of propofol solution at the time of administration if the propofol solution had been contaminated at the point of manufacture many weeks or months earlier. This review will also be submitted as a manuscript for a peer reviewed journal [Appendix 5, Chapter 5.1].

Report on a project to a non-scientific audience or in the form of a ministerial brief
I contributed to the write up of multiple reports to the CDNA and Australian Health Principal Protection Committee reporting on the findings of the investigation into the cluster of cases *Ralstonia* bacteraemia. The final multi-jurisdictional report is shown in Appendix 3 of Chapter 5.1.

I also provided input and/or contributed to the write up of the following ministerial briefs *(these reports are not included in this bound volume)*:

1. Minute to the Deputy Secretary on ‘Projects to address the high rates of childhood anaemia in the Northern Territory as evident in the Northern Territory Aboriginal Health Key Performance Indicators.’
3. I wrote a ‘Delegate Briefing Paper’ on a 2012-13 and 2013-14 AIHW report on Hearing Health Outreach Services to Indigenous children and young people in the NT.
4. Minute to the Minister on the Northern Territory Aboriginal Health Key Performance Indicators.
5. Information brief: East Arnhem.

Conference and other presentations
I presented a paper titled *Evaluation of the Northern Territory Aboriginal Health Key Performance Indicators* to participants of the Continuous Quality Improvement (CQI)
Collaborative Workshop held in Darwin in the NT, 10 - 11 November 2015. My objectives were to inform them on the evaluation of the NT AHKPIs, its utilisation focused approach, and the preliminary findings; I also sought their suggestions for recruiting more responses related to the questionnaire I developed for the evaluation [Appendix 9, Chapter 4].

I presented my experiences from the field supporting WHO in their response to the EVD outbreak in Sierra Leone to the IHD on 28 October 2015 [Appendix 1, Chapter 5.2].

**Prepare and conduct a teaching lesson for peers including a lesson from the field**

I participated in seven lessons from the field (I missed two while I was in Sierra Leone). One of these included one that I prepared for my peers on 24 February 2015.

The objectives of my lesson from the field were to:

1. explore reasons why a specific set of guidelines is needed to cover research in Aboriginal and Torres Strait Islander people;
2. list and explain the six core values that underpin the guidelines for ethical conduct in Aboriginal and Torres Strait Islander Health Research;
3. apply the six core values to one of your own MAE projects; and
4. discuss the implications of not considering these values in the design and conduct of Aboriginal and Torres Strait Islander health research.

I contributed to and participated in a half-day teaching exercise conducted for first year MAE scholars in March 2015. My MAE colleagues and I presented a lesson on ‘Bias in interpreting Aboriginal and Torres Strait Islander health data’.

The objectives of our teaching session were to:

1. describe and interpret a graph;
2. explain bias and the two major types of bias; and
3. identify biases in Aboriginal and Torres Strait Islander health data.

Records of these teaching activities are not shown in this bound volume.
Respond appropriately to public health enquiries
I responded regularly to, and assisted with, analysing, interpreting and reporting on data, as well as contributing to ministerial briefs (listed above) under ‘Report on a project to a non-scientific audience or in the form of a ministerial brief’ section of this chapter.

I contributed regularly to the International Communicable Disease Surveillance Report for CDNA on a roster with other MAEs at the Office of Health Protection at the Commonwealth Department of Health.

Attend all residential teaching course blocks
I attended all of the MAE four residential teaching course block sessions in February/March and August/September 2014, and February/March in 2015.
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Closed chapter - not presented in this thesis.

“Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination.” (1)

**MAE course requirement:** Data Analysis
Chapter 3 - Evaluation of the Northern Territory Aboriginal Health Key Performance Indicators

**MAE requirement:** Evaluation of a Health Information System
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Preface

Investigatory role
With much guidance from my supervisors, and in collaboration with the Northern Territory Aboriginal Health Key Performance Indicator (NT AHKPI) steering committee, I designed the methodology for the evaluation, completed the applications to ethics committees, and conducted the collection, analysis and interpretation of the data, writing the final report and reporting back to stakeholders and participants.

Lessons learnt
Although the benefit of conducting an utilisation-focused evaluation (UFE) is that it generates findings that are useful to stakeholders to inform decisions and improve performance, there are challenges to developing this approach. It requires a lot of time, flexibility, ongoing engagement and trust between the stakeholders and the evaluators. These challenges take time to overcome, an activity constrained by the short-time frame of the MAE program. It took us approximately nine months to get consensus from stakeholders on the study design, and a further seven months to obtain the required ethics and other approvals to start the evaluation. This left us with very little time to conduct the evaluation, interpret the results and develop the recommendations. These time constraints compromised our response rate and made it difficult to draw meaningful conclusions and recommendations for the stakeholders.

Notwithstanding, the UFE approach was appropriate for this evaluation because its purpose was not to prove but to help improve the NT AHKPI system, and to empower the stakeholders to review the goals and modify the system for effectively achieving its goals (1).

Even with more time, it still would have been challenging to improve on the response rate from staff of busy PHC services. Ideally, I would have visited a sample of PHC services to both optimise the response rate, and gain a better understanding of how the indicators are used and how the system could be improved.
Identifying and designing a method for evaluating a system for monitoring indicators where there was no pre-existing method (e.g. the CDC guidelines for evaluating a surveillance system) was challenging. It took time both to learn about the NT AHKPI system and to learn about other methods of evaluating this system. This project would not have been possible without the guidance I received from Mahomed Patel and the steering committee.

**Potential public health impact**

I shared initial findings with stakeholders and they requested that I continue to collect questionnaire data to collect stronger more meaningful evidence. This study is therefore still a work in progress.

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This project would not have been possible without the support and guidance from:

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- Dr Liz Moore, AMSANT
- Rachel Meyer, Brendan Gibson, Hope Peisley, Dr Masha Somi, Indigenous Health Division, Australian Government Department of Health
- NT AHKPI steering committee
- AMSANT
- NT DoH
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACE</td>
<td>Angiotensin Converting Enzyme</td>
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<tr>
<td>ACCHO</td>
<td>Aboriginal Community Controlled Health Organisation</td>
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<tr>
<td>AMSANT</td>
<td>Aboriginal Medical Services Alliance Northern Territory</td>
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<tr>
<td>ARB</td>
<td>Angiotensin Receptor Blocker</td>
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<tr>
<td>ARF</td>
<td>Acute rheumatic fever</td>
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<tr>
<td>BP</td>
<td>Blood pressure</td>
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<tr>
<td>BPG</td>
<td>Benzathine Penicillin G</td>
</tr>
<tr>
<td>CARPA</td>
<td>Central Australian Rural Practitioners Association</td>
</tr>
<tr>
<td>CHC</td>
<td>Community Health Centre Report</td>
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<tr>
<td>COAG</td>
<td>Council of Australian Governments</td>
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<tr>
<td>CRC</td>
<td>Cooperative Research Centre</td>
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<tr>
<td>CRG</td>
<td>Clinical reference group</td>
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<tr>
<td>DoH</td>
<td>Department of Health</td>
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<tr>
<td>ESSENCE</td>
<td>Essential service standards project</td>
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<tr>
<td>HbA1c</td>
<td>Glycosylated haemoglobin test</td>
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<tr>
<td>HSDA</td>
<td>Health service delivery area report</td>
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<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
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<tr>
<td>MBS</td>
<td>Medicare Benefit Schedule</td>
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<tr>
<td>nKPIs</td>
<td>National Key Performance Indicators</td>
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<tr>
<td>NT</td>
<td>Northern Territory</td>
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<tr>
<td>NT AHF</td>
<td>Northern Territory Aboriginal Health Forum</td>
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<tr>
<td>NT AHKPI</td>
<td>Northern Territory Aboriginal Health Key Performance Indicators</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PCIS</td>
<td>Primary Care Information System</td>
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<tr>
<td>PHC</td>
<td>Primary Health Care</td>
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<tr>
<td>RHD</td>
<td>Rheumatic heart disease</td>
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Abstract

Background
The Northern Territory Aboriginal Health Key Performance Indicators (NT AHKPIs) are a collection of key performance indicators (KPIs) designed to measure performance of primary health care (PHC) services in the NT (2). There are currently 16 KPIs (two of which are sub component KPIs) that provide information on both process of care and health outcomes in the areas of maternal and child health and chronic disease services at the PHC level. The NT AHKPIs were introduced in 2009 and are currently collected from 84 PHC services, including both Northern Territory (NT) Department of Health (DoH) services and Aboriginal Community Controlled Health Organisations (ACCHOS). The goals of the system are ‘To improve Primary Health Care (PHC) services for Aboriginal Australians in the NT by building capacity at the service level and the system level to collect, analyse and interpret data to:

1. Inform understanding of trends in individual and population health outcomes;
2. Identify factors influencing these trends; and
3. Inform appropriate action, planning and policy development.’

Although the KPIs have been used for planning of PHC services and CQI, the system has not been evaluated. The objectives of this evaluation were to assess:

1. whether the KPIs are addressing the intended goals of the monitoring system;
2. whether the KPIs are being used for other purposes; and
3. how the system could be improved for greater usefulness.

Methods
We chose two key approaches: 1) to evaluate each indicator and 2) assess the usefulness of the system as expressed by key stakeholders. I evaluated the individual KPIs using criteria recommended by the Organisation for Economic Co-operation and Development (OECD) for evaluating health indicators. I then developed two questionnaires to assess how the results were being used: one was targeted to users of the KPIs at the PHC level and the other, to higher level planners such as steering committee members, and staff at NT DoH and AMSANT.
Results

KPIs assessed against the OECD criteria

Importance and impact of what is being measured
All the KPIs measure disease areas that affect Aboriginal and Torres Strait Islanders disproportionately when compared with non-Indigenous Australians. Policy makers and consumers were concerned of the disease condition related to all the KPIs.

Can the health care system meaningfully address this disease area problem?
Yes - all disease areas are part of the core functions to be addressed by Aboriginal and Torres Strait Islander PHC services in the NT. Although they are influenced by a range of social and environmental health determinants, many of which go beyond the domain traditionally covered by PHC services.

Scientific soundness

Validity: are the data telling the truth?
Systematic checks of the data are performed by the NT DoH to detect and remove errors. However, these checks do not identify all incorrect data entry errors or incomplete data. Double counting of clients is an issue for ACCHOs that use Communicare.

Reliability: does the measure provide stable results across various populations and circumstances?
Most of the KPIs (13/16) have had changes to the definitions for either the numerator or denominator, but these changes have been well documented for trends to be interpreted meaningfully over time. Because zero reporting is not used, blank cells could imply either missing data or a zero. However, overall completeness of the data has improved substantially since the system was first implemented.

Is there scientific evidence to support the measure?
There is scientific evidence to support nine out of the 16 KPIs, although three of these are outcome indicators (KPIs 3, 5 and 6) and are therefore not good indicators of service performance. Seven out of 16 KPIs measure whether someone has been tested/screen for an abnormality but no data are recorded on the action and care provided following if an abnormality was detected.
Results from the questionnaires to PHC services on the usefulness of the indicators

Of the questionnaires sent to 84 PHC services (52 NT DoH and 32 ACCHOs) only 13 responded, covering 23 services. Sixty-two percent (8/13) of respondents use the indicators for service planning, CQI and feedback to communities. Fifteen percent (2/13) use them for service planning and CQI only, 15% (2/13) use them for service planning only, and one uses them for CQI and feedback to communities. Overall, most respondents (69%) found the indicators to be ‘very useful’ for service planning, and CQI, and half of the respondents found them ‘very useful’ for feedback to communities. Ninety-two percent (12/13) reported the indicators to be valuable. Participants explore variations in the indicators by speaking with other staff and with the community, and cross referencing with other reports.

Results from questionnaires to higher level planners

We received eight questionnaires from higher level planners. Eighty-five percent (11/13) use the reports for CQI and supporting services in their planning and 18% (2/11) can’t access the reports. Overall, most respondents (71%) found the indicators to be ‘very useful’ for planning, and CQI (80%), but less than half found them ‘very useful’ for policy development. The higher level planners use other reports and datasets to explore variations in trends of the indicators. Thirty-eight percent (3/8) thought that there are changes that could be made to the governance of the NT AHKPIs that would support continuous improvement of the system and 68% (5/8). Suggested improvements included: promoting the reports and making them more widely available; improving the comparability between data from PCIS and Communicare; and giving Communicare the ability to collect data across multiple clinics for one client.

For both staff at the PHC level and higher level planners, data on trends were the most useful aspects of the Community Health Centre (CHC) and the Health Service Delivery Area (HSDA) reports. Overall weaknesses of the reports were that they contain too much data while lacking context, and they aren’t sent frequently enough.
Conclusion

Findings from the questionnaires revealed that the KPIs are considered a very valuable tool being used to inform planning of PHC services, but information on whether the action and planning is ‘appropriate’ is not collected. The results of KPIs cannot address objectives 1 and 2 (‘inform understanding of trends in individual and population health outcomes’ and ‘identify factors influencing these trends’) because data aren’t collected on the social and environmental determinants related to the health conditions and events being measured.

The response rate for our study was very small and therefore unlikely to be representative of the study population of health staff related to the PHC services. This limits us from being able to draw meaningful or generalizable conclusions or recommendations until in-depth interviews and focus group discussions can be conducted with all relevant staff. We need more robust evidence to assess whether the indicators are addressing their intended goals effectively, and how the system could be improved for greater usefulness.
Background
In 1999 the Northern Territory Aboriginal Health Forum (NT AHF) identified the need to identify and monitor a common set of indicators on process of clinical care and health outcomes referred to as the ‘key performance indicators’ (KPIs). The KPIs were designed to inform planning of primary health care (PHC) services in the Northern Territory (NT) (2). The set of KPIs were focused on specific outcomes related to the management of chronic disease, antenatal care, and infant, child and adult health.

An extensive amount of work went into the design and development of the indicators. Pam Gollow (project manager on the development of the NT AHKPIs) detailed this process in the document titled ‘The development of a performance reporting system for Indigenous primary health care’ (3). The document included literature reviews of indicator sets used for performance measurement in the health sector and multiple workshops to brainstorm ideas, to establish an agreed understanding of the purpose of a performance reporting system, to develop a framework to guide its development and to establish criteria for selecting the indicators that were listed as:

1. ‘Is the measure useful from the service provision point of view?'
2. 'Is the measure useful from the funding point of view?'
3. ‘How frequently should the measure be reported?'
4. ‘Is data available / are there any quality issues?’

Workshop participants (Listed in Table 1) used these criteria to include or exclude indicators. By the end of this process, of the eligible 44 KPIs, 12 were accepted for inclusion. Since then a further three KPIs (KPIs numbers 13 - 15) were accepted for use in 2013 based on suggestions from the clinical reference group (CRG) (Appendix 1). A list of the organisations and individuals involved in the development of the NT AHKPIs is shown in Table 1 and the development process is shown in Figure 1.
Table 1: Organisations and individuals involved with the development of the KPIs

<table>
<thead>
<tr>
<th>Project team</th>
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<tbody>
<tr>
<td>Project advisor: Professor Tony Barnes</td>
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<tr>
<td>Cooperative Research Centre (CRC) Program leader: Dr Ross Bailie</td>
</tr>
<tr>
<td>Project Manager (part-time): Pam Gollow</td>
</tr>
<tr>
<td>Project Officer (casual): Dr George Latham</td>
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<tr>
<th>Steering Committee</th>
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<tr>
<td>The Primary Health Care Steering Committee included representatives from three partners of the Aboriginal Health Forum (AHF):</td>
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<tr>
<td>-NT Department of Health</td>
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<tr>
<td>-The Commonwealth Department of Health</td>
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<tr>
<td>-Aboriginal Medical Services Alliance of the Northern Territory (AMSANT)</td>
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<tr>
<th>Northern Territory Aboriginal Health Forum (NTAHF)</th>
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<tr>
<td>-Aboriginal Medical Services Alliance Northern Territory (AMSANT)</td>
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<tr>
<td>-Northern Territory Department of Health</td>
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<tr>
<td>-Commonwealth Department of Health</td>
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</table>

Broad consultation with a range of key stakeholders and experts throughout the whole project. These experts included: Indigenous health service providers and managers, health specialists, information technology experts, finance officers, epidemiologists and demographers.

Figure 1: Flowchart of workshop and consultation process (3)
The NT AHKPIs are a collection of indicators that measure the performance of PHC services (4). There are currently 16 KPIs (two of which are sub component KPIs) to monitor both process of care and health outcomes in the areas of chronic disease, antenatal care, and infant, child and adult health at the primary health care (PHC) level (Appendix 1). The NT AHKPIs were introduced in 2009 and are currently collected from 84 primary health care services, including both Northern Territory (NT) Department of Health (DoH) services (52 services) and Aboriginal Community Controlled Health Organisations (ACCHOS) (32 services). The system’s goals are stated as:

‘To improve Primary Health Care (PHC) services for Aboriginal Australians in the NT by building capacity at the service level and the system level to collect, analyse and interpret data to:

1. Inform understanding of trends in individual and population health outcomes;
2. Identify factors influencing these trends; and
3. Inform appropriate action, planning and policy development’ (5).

Continuous Quality Improvement and the NT AHKPIs
A major use of the NT AHKPIs has been for continuous quality improvement (CQI) of PHC services as well as for clinical data audits. CQI is defined as ‘the use of good quality data about systems, processes and outcomes to assist health care teams to develop and implement plans for improving the quality of care provided to patients and to communities, and to do this in a cyclical and ongoing approach’ (6). It is the ongoing collection, use and analysis of data on organisational system performance, to facilitate continuous improvement of primary health care delivery (7, 8).

Data and reporting of the indicators
The NT AHKPI consists of clinical data already being collected as part of the normal functioning of the PHC services. The necessary data that make up the 16 KPIs are forwarded from electronic record systems at each of the PHC services and sent to a central data repository at the NT DoH corporate data warehouse, on six a monthly basis for a 12-month reporting period. In the NT there are two electronic patient information systems that are used: Communicare and Primary Care Information System (PCIS). Within both of these systems there is an inbuilt mechanism for reporting of NT AHKPI data. At
the NT DoH corporate warehouse, the data are checked. The data are then sent back to the PHC services in the form of a report to give services the opportunity to review the data and provide any contextual or interpretive information.

Three different reports summarise the NT AHKPIs for use by service providers and higher level planners, but are not for public distribution.

1. Community Health Centre (CHC) report – summarises the KPIs for each of the PHC services for the last reporting period and for all reporting periods. It provides a comparison to the NT average. This report is distributed to PHC services at 6 monthly intervals.
2. HSDA report – summarises the KPIs for each of the health service delivery areas for the last reporting period and for all reporting periods. It provides a comparison to the NT average. This report is distributed to the NT AHF at 6 monthly intervals.
3. De-identified HSDA report – same as the above but de-identified (2).

The objectives of this evaluation
Although the KPIs have been used for planning of PHC and CQI at the service level since the introduction of the system in 2009, the system has not been evaluated. The objectives of this evaluation were to assess:

1. whether the KPIs are addressing the intended goals of the monitoring system;
2. whether the KPIs are being used for other purposes; and
3. how the system could be improved for greater usefulness.

Methods
My approach to this evaluation was utilisation-focused where the primary purpose was to generate information meaningful for the stakeholders to continue strengthening and developing the KPIs aimed at strengthening PHC services and health outcomes among Aboriginal and Torres Strait Islanders.

Utilisation-focused evaluation
Because the overall aim of the evaluation was to help assess and to strengthen this system, we opted for an utilisation focused approach which ‘begins with the premise that
evaluations should be judged by their utility and actual use’ (9). This approach was developed by Michael Patton and is based on the principle that an evaluation should be planned and designed in a way that generates findings that are useful to stakeholders of the project to inform decisions and improve performance. One of the essential elements of a utilisation-focused evaluation (UFE) is that users of the system are engaged from the beginning and throughout every phase of the evaluation; with formulating key questions, the design and data collection tools, analysis, interpretation, recommendations are all done in collaboration with people who use the system and have the ability to implement the changes recommended by the evaluation.

To address the objectives of the evaluation, we chose two key approaches: 1) to evaluate each indicator and 2) assess the usefulness of the system as expressed by key stakeholders drawing on surveys of all people who use the indicators at the PHC level and of higher level planners, and a review of documents. These documents include: a review of literature and a review of the ‘Definitions’ manuals (10) for the indicators and the ‘Data Receiving Protocol’ which outlines the processes and rules for extraction of the data (5). Specific evaluation questions and methods for data collection are outlined in Table 2.
<table>
<thead>
<tr>
<th>NT AHKPI objective</th>
<th>Evaluation question</th>
<th>Suggested method to answer questions</th>
<th>Data sources</th>
<th>People to interview</th>
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<tbody>
<tr>
<td>1. To inform understanding of trends in individual and population health outcomes</td>
<td>Are the KPIs important and scientifically sound?</td>
<td>Assess the appropriateness of the KPIs using internationally recognised criteria for evaluating indicators posed by Organisation for Economic Co-operation and Development (11)</td>
<td>The KPIs</td>
<td>N/A</td>
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<td></td>
<td>Do the analyses and interpretation of the data describe and explain trends in individual and population outcomes?</td>
<td>Review NT AHKPI community and health service area reports</td>
<td>Community health centre report Regional health centre report available on the NT AHKPI website (<a href="http://www.nt.gov.au/health/ahkpi/">http://www.nt.gov.au/health/ahkpi/</a>)</td>
<td>N/A</td>
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<td></td>
<td>Is this information disseminated in an appropriate and timely manner to the intended users responsible for taking action?</td>
<td>Confirm with the steering committee who the information was intended to reach, and how the recipients were expected to use and act on the information</td>
<td>Questionnaire to members of steering committee and CQI facilitators</td>
<td>- Ask all steering committee members if they would like to participate either via email - CQI coordinators and facilitators (Contact PHC CEO to request permission to obtain contact details for the CQI coordinators)</td>
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<td></td>
<td></td>
<td>Interview health staff from PHC services across NT</td>
<td>Send questionnaire electronically to all 84 services Send questionnaire electronically to CQI facilitators</td>
<td>All 84 services CQI coordinators and facilitators (Contact PHC CEO to request permission to contact &amp; obtain contact details for CQI coordinator)</td>
</tr>
<tr>
<td>NT AHKPI objective</td>
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|                    | How do you explore variations you see in your NT AHKPIs over time? (e.g. explore other data sources such as workforce data or speak to the community or staff) | -Interview health staff from PHC  
-Interview steering committee, clinical reference group, AMSANT staff, NT DoH and Commonwealth Department of Health | -Send questionnaire electronically to all 84 services  
-Send questionnaire to members of steering committee and AMSANT  
-Physically give questionnaire to Commonwealth DoH | -All 84 services  
-Ask steering committee members who would like to take part in the evaluation  
-Contact Liz Moore (member of AMSANT) and ask for her advice on the best way to approach members of AMSANT  
-Questionnaire to identified Commonwealth Department of health staff |
| 2.To identify factors influencing these trends | How do you explore variations you see in your NT AHKPIs over time? (e.g. explore other data sources such as workforce data or speak to the community or staff) | -Interview health staff from PHC  
-Interview steering committee, clinical reference group, AMSANT staff, NT DoH and Commonwealth Department of Health | -Ask NTG data managers (Liana Riley and Daniel Atkins) directly | -Liana Riley and Daniel Atkins |
|                    | Interview steering committee, AMSANT staff, NT DoH and Commonwealth Department of Health staff | -Send questionnaire to members of steering committee and AMSANT.  
-Physically give questionnaire to Commonwealth DoH | | -Ask steering committee members who would like to take part in the evaluation  
-Contact Liz Moore (member of AMSANT) and ask for her advice on the best way to approach members of AMSANT  
-Questionnaire to Commonwealth Department of health staff |
|                    | -Review NT AHKPI documents and interview NTG data managers about data flow and feedback loops | | | -Liana Riley and Daniel Atkins |
|                    | -Send questionnaire to members of steering committee and AMSANT  
-Physically give questionnaire to Commonwealth DoH | | | -Ask steering committee members who would like to take part in the evaluation  
-Contact Liz Moore (member of AMSANT) and ask for her advice on the best way to approach members of AMSANT  
-Questionnaire to Commonwealth Department of health staff |
|                    | -Send questionnaire electronically to all 84 services  
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-Questionnaire to identified Commonwealth Department of health staff |
|                    | -All 84 services  
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<td></td>
<td>Were the factors described in the NT AHKPI system documents and community and health service area reports?</td>
<td>Review NT AHKPI documents and community health centre and health service delivery area reports</td>
<td>-NTAHKPI documents listed at: <a href="http://www.nt.gov.au/health/ahkpi/">http://www.nt.gov.au/health/ahkpi/</a> -Community health centre report -Regional health centre report</td>
<td>N/A</td>
</tr>
<tr>
<td>3. To inform appropriate action, planning and policy development</td>
<td>Once you have explored variations in your NT AHKPIs, how do you act on the findings to a) improve service performance b) to make future plans?</td>
<td>-Interview health staff from PHC services across NT -Interview CQI facilitators and 2 coordinators -Interview steering committee, clinical reference group, AMSANT staff, NT DoH and Commonwealth Department of Health to ask what these factors are and how they are collected</td>
<td>-Send a questionnaire electronically to all services -Send questionnaire electronically to CQI facilitators</td>
<td>-All 84 services -Contact PHC CEO and request permission to contact and obtain contact details for the CQI coordinator -Ask steering committee members who would like to take part in the evaluation -Contact Liz Moore (member of AMSANT) and ask for her advice on the best way to approach members of AMSANT -Give questionnaire to identified Commonwealth Department of health staff</td>
</tr>
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<td></td>
<td>Is there evidence that the NT AHKPIs have been used at the service for service planning, CQI and community feedback?</td>
<td>Survey/interview CQI facilitators and 2 coordinators, steering committee, AMSs, AMSANT staff, NT DoH and Commonwealth Department of Health</td>
<td>-Send questionnaire electronically to all services -Send questionnaire electronically to CQI facilitators -Send questionnaire to members of steering committee and AMSANT. -Physically give questionnaire to</td>
<td>-All 84 services -Contact PHC CEO and request permission to contact and obtain contact details for the CQI coordinator -Contact Liz Moore (member of AMSANT) and ask for her advice on the best way to approach members of AMSANT</td>
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<td></td>
<td>Is there evidence that the NT AHKPIs have been used at a planning and policy?</td>
<td>Case studies e.g. NT &amp; Commonwealth Department of Health along with other stakeholders noticed that the anaemia KPI was high and remaining high. This prompted action from a variety of different groups to try to understand why this was happening and what can be done to try to fix this problem.</td>
<td>Commonwealth DoH</td>
<td>AMSANT - Ask steering committee members who would like to take part in the evaluation - Give questionnaire to identified Commonwealth Department of health staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Survey/interview steering committee, AMSANT staff, NT DoH and Commonwealth Department of Health about how programs have responded.</td>
<td>-Send questionnaire to members of steering committee, AMSANT, CRG, NT DoH - Physically give questionnaire to Commonwealth DoH</td>
<td>-Contact Liz Moore (member of AMSANT) and ask for her advice on the best way to approach members of AMSANT - Ask steering committee members who would like to take part in the evaluation - Give questionnaire to identified Commonwealth Department of health staff</td>
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</tbody>
</table>
|                    | What are the processes to transform information from the system into action, planning and policy development? | Survey/interview steering committee, AMSANT staff, NT DoH and Commonwealth Department of Health | -Send questionnaire to members of steering committee, AMSANT, NT DoH  
-Physically give questionnaire to Commonwealth DoH | -Ask steering committee members who would like to take part in the evaluation  
-Contact Liz Moore to ask for her advice on the best way to approach members of AMSANT  
-Give to identified Commonwealth Department of health staff |
|                    | What are the governance arrangements for the NT AHKPI system?  
-Send questionnaire to members of steering committee, AMSANT, NT DoH, CQI facilitators  
-Physically give questionnaire to Commonwealth DoH | -Contact PHC CEO and request permission to contact and obtain contact details for the CQI coordinator  
-Contact Liz Moore to ask for her advice on the best way to approach members of AMSANT  
-Ask steering committee members who would like to take part in the evaluation  
-Give to identified Commonwealth Department of health staff |
| To explore how else, the NT AHKPIs are used | How do you or your service use the NT AHKPIs  
What value do you see to the NT AHKPIs? | Interview health staff from PHC services across NT | Send questionnaire electronically to all 84 services | All 84 services |
Assessing the NT AHKPIs using criteria of the Organisation for Economic Co-operation and Development for evaluating KPIs

I evaluated the individual KPIs using criteria recommended by the Organisation for Economic Co-operation and Development (OECD) for evaluating KPIs (Appendix 2). I modified the criteria by excluding the one criteria of ‘feasibility of obtaining internationally comparable data’ as it was not relevant for our evaluation.

Questionnaires

I developed two questionnaires in close collaboration with members of the steering committee and with staff in the Indigenous Health Division at the Australian Commonwealth Department of Health. One targeted to users of the KPIs at the PHC level and the other targeted to higher level planners such as steering committee members, and staff at NT DoH and AMSANT. I conducted the surveys using SurveyMonkey, a free online tool for creating online surveys (12).

I first piloted the questionnaires for PHC planners with staff of one PHC service in the NT, to staff at NT DoH and AMSANT as well as to the higher level planners of NT DoH and AMSANT.

After revising the questionnaires, I sent the survey-link to the Chief executive officer (CEO) of AMSANT for distribution to all CEOs of ACCHOs (n=32) and to a general manager at NT DoH for distribution to all CEOs of NT DoH services (n=52). The questionnaires and information provided to participants in survey monkey are shown in Appendices 3 to 6.

To optimise participation rates, we tried to reach and inform more people about the evaluation through the Communicare newsletter (Appendix 7), and I presented the evaluation at the ‘CQI Collaborative Workshop’ in Darwin in the NT from 10 and 11 of November 2015 (Appendix 8).
**Ethics**

I obtained ethics approvals from the following ethics committees and organisations:

1. The Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research - HREC-2015-2357
2. The Central Australian Human Research Ethics Committee - HREC-15-300
3. The Australian National University Human Research Ethics Committee - 2015/324
4. AMSANT
5. NT DoH
6. NT AHKPI steering committee

I started the ethics approval process in March 2015 and received my final approval to proceed with the evaluation in September 2015.

**Analysis**

I provided descriptive summaries for the assessment of the KPIs using the OECD criteria, and descriptive summaries for the responses to both of the questionnaires.

**Findings**

*Summary of assessment of the NT AHKPIs using the Organisation for Economic Co-operation and Development criteria for evaluating KPIs*

In this section I describe the findings based on the OECD assessments of the individual indicators. This is then followed by the individual assessments for each of the KPIs.

*Importance of what is being measured*

*What is the impact on health and on health expenditure?*

With the exception of KPI 1 (which does not measure any specific disease outcomes), the other KPIs measure outcomes that have a negative impact on the health of Aboriginal and Torres Strait Islanders. For all disease areas measured, there is a gap between the actual and potential levels of achievable health. Moreover, all the disease areas measured, affect Aboriginal and Torres Strait Islanders disproportionately when compared with non-Indigenous Australians.
Are policy makers and consumers concerned about the disease?
Policy makers and consumers were concerned of the disease condition related to all the KPIs. All disease areas (with the exception of KPI 1) are discussed in the Aboriginal and Torres Strait Islander Health Performance Framework\(^1\) (13).

Can the health care system meaningfully address this disease area problem?
All disease areas are part of the core functions to be addressed by Aboriginal Primary Health care services in the NT. Although each of these disease areas has their own unique challenges to delivery, they are also influenced by a range of social and environmental health determinants, many of which go beyond the domain traditionally covered by PHC services. While, the PHC system can contribute to addressing these disease areas, the environmental and social determinants of health must be addressed to improve health outcomes.

Scientific soundness

Validity: are the data telling the truth?

Does the information collected measure what it is supposed to measure? (I.e. has the indicator been tested and validated to measure what it is intended to measure?)

Each of the KPIs has its unique limitations (outlined in the next section of this chapter), but general limitations that apply to all the KPIs are as follows:

1. Residents seeking treatment outside of the local PHC service will not be included in these KPIs for that service.

2. The data reflect only what has been documented in the electronic patient record. The KPIs rely on correct information being entered into the electronic database and being correctly extracted by the NT DoH warehouse. If a client is not entered into the system, they will not be captured in the KPIs. If a health worker enters incorrect results into the system, this will bias assessment of indicators.

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\(^1\) The Aboriginal and Torres Strait Islander Health Performance Framework was developed to support a coordinated approach to address the complex factors that contribute to the poor health outcomes of Aboriginal and Torres Strait Islander Australians. The report is considered the evidence base for Aboriginal and Torres Strait Islander health policy. [http://www.health.gov.au/indigenous-hpf](http://www.health.gov.au/indigenous-hpf)
3. If there are uncertainties on the total number of residents in the community (the denominator population), results of KPIs based on estimates of proportions will be biased.

Do the results fall within a plausible range?
For KPI 7 - one service reported numerators of resident clients on a chronic disease management plan that exceeded the denominator population yielding proportions for that service of 108% in 2010 and 128% in 2011. All other calculated proportions for the remaining KPIs and PHC services were within plausible ranges (0% and 100%).

Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?
Systematic checks of the data are performed once the data reach the NT DoH warehouse. If the data do not meet the rules [outlined in the Data Receiving Protocol (DRP)] (5), the submission of the data fails and a violation report is sent to the AHKPI team who then contacts the PHC service to investigate the problem. Once the data are submitted (and meets the DRP rules) an initial report is generated, spot checked for errors and compared to previous reports at the NT DoH warehouse. If errors are detected, the PHC service is requested to resubmit data and reports are re-generated and checked again. Acceptable reports are sent out to the PHC services once more to comment on data quality; if the services detect errors at this point, the services are encouraged to contact the AHKPI team to arrange for re-submission of the data. These system checks do not identify incomplete data or all data entry errors as described in the previous section.

These system checks also do not assess the variability of different testing devices (such as the HemoCue that measures levels of haemoglobin to screen for anaemia) used in different PHC services and whether these testing devices have been standardised regularly and/or stored appropriately.

Double counting of clients is also an issue for ACCHOs that use the Communicare patient information system but not for NT DoH PHC patients because their electronic information systems are linked. Someone who has attended a NT DoH service may also
be counted in an ACCHO service, and there may also be double counting of clients between ACCHOs.

**Reliability: does the measure provide stable results across various populations and circumstances?**

Have the data collection methods for measuring, calculating or recording this KPI changed over time?
Yes, all KPIs have had some changes since the system was implemented. KPIs 3, 4.2 and 13 have had minor changes that are unlikely to affect comparisons over time.

The other KPIs (1, 2, 5 - 12, 14) have had major changes to either of the definitions of the numerator and/or denominator and therefore direct comparisons between years should be made with caution.

**How complete are the data?**

Overall, the completeness of the data has improved since the system was first implemented. In 2010, all KPIs had at least one PHC service (range 1 to 4 PHC services) that didn’t report any data (numerator and denominator) data. In 2011, 11/12 KPIs had at least one PHC service that did not report any data (range 1 to 5 PHC services). In 2012, all services reported on all of the KPIs. In 2013, at least one PHC service did not report any data for 3 out of the 15 KPIs, and in 2014 at least one PHC service (range 1 to 8 PHC services) did not report on 4 out of the 16 KPIs (Table 3).

The KPIs for all reporting years had at least one numerator cell that was left blank (details shown under the individual KPI assessments). One KPI had up to 78 blank numerator cells (KPI 11). Because zero reporting is not used in the NT AHKPI reporting system, blank cells could imply either missing data or a zero.
Table 3: The number of PHC services that did not report data (numerator and denominator data) by KPI and reporting year

<table>
<thead>
<tr>
<th>KPI</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4.1</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4.2</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8.1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8.2</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>11</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>13</td>
<td>8</td>
</tr>
</tbody>
</table>

*N/A means data were not collected for these KPIs during that reporting year

Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?

Yes, all the data collection and analysis methods are documented for all KPIs in ‘Northern Territory Aboriginal Health Key Performance Indicators System: Data Receiving Protocol, October 2013, Version 2.05’ (5).

Is there scientific evidence available to support the measure?

The following KPIs have been recommended by EURO-PERISTAT and/or WHO, or are internationally recognised, or there is evidence to support the measure:

1. KPI 2 - timing of first antenatal visit;
2. KPI 3 - proportion of low birth weight infants;
3. KPI 4.1 and 4.2 – proportion of children fully immunised and who are immunised on time;
4. KPI 5 - proportion of children < 5 years who are underweight;
5. KPI 6 - proportion of children who are anaemic; and
6. KPI 7 - proportion of clients with type 2 diabetes and/or coronary heart disease and who have a chronic disease management plan
7. KPI 12 – proportion of women who have had at least one Pap smear test.
Chapter 3

8. KPI 14 - proportion of clients with ARF /RHD who are prescribed to be requiring 2-4 weekly BPG penicillin prophylaxis and have received injections

Although there is scientific evidence to support these, KPIs 3, 5, and 6 are highly influenced by a range of socioeconomic and environmental factors that are beyond the domain of PHC services and therefore are not good indicators of service performance.

The following KPIs measure only whether someone has been tested / screened for an abnormality, but no data are recorded on the action and quality of care provided following if an abnormality was detected.

1. KPI 8.1 – proportion of clients who have had an HbA1c test;
2. KPI 8.2 – proportion of clients whose HbA1c levels are within certain levels
3. KPI 9 – proportion of diabetic patients with albuminuria who are on ACE/and or ARB;
4. KPIs 10 and 11 – proportion of clients who had a full adult check;
5. KPI 12 – proportion of women who had at least one pap smear test; and
6. KPI 13 – proportion of clients who have type 2 diabetes and have good blood pressure control.

KPI 1 monitors only the workload for a PHC service and can be used for planning and resource allocation. It does not measure the content or quality of the services provided.
Individual KPI assessments

KPI 1 - ‘Number of episodes of health care and client contacts’ (10)

Rationale

‘Measures the uptake of the service as well as equity in access to health services between health centres within a Health Service Delivery Area’ (10).

Definition

1. ‘Episode: An ‘episode of care’ is contact between an individual client and a service by one or more staff to provide health care. For example, an episode of care that is provided for a client’s sickness, injury, counselling, health education, screening, or other health related issues. An episode of care begins when a client visits a health service to receive health care. A client may be seen by an Aboriginal Health Worker, and/or a Nurse and/or a GP during an episode of care. This represents one episode of care. If this client comes back another day, this is a second episode care. In NT AHKPI, an episode of health care includes:
   a. episodes of health care delivered over the phone
   b. episodes of residential care

2. Client contact: The numbers of health professionals who have contact with a client during an episode of health care. For example, if a client saw three different health professionals, Aboriginal Health Worker, and a Nurse and a GP in an episode of care, this would equal three client contacts. Telephone consultation: are clinical consultations that are to do with client clinical advice and result in a dated entry being made in the client health record’ (10).

Importance of what is being measured

<table>
<thead>
<tr>
<th>What is the impact on health and on health expenditure?</th>
<th>This indicator provides information only on volume of care provided by the PHC service. In 2011-2012, the second largest component of health spending in Australia was for PHC services - $50.6 billion or 36.1% of total health expenditure (14).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are policy makers and consumers concerned about the disease?</td>
<td>Not applicable because this indicator does not measure any specific diseases.</td>
</tr>
<tr>
<td>Can the health care system meaningfully address this disease area problem?</td>
<td>Not applicable because this indicator does not measure any specific diseases.</td>
</tr>
</tbody>
</table>
### Scientific soundness

#### Validity: are the data telling the truth?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</strong></td>
<td>Yes, this indicator measures what it is supposed to measure - how many client contacts and episodes of care have occurred within the reporting period.</td>
</tr>
</tbody>
</table>
| **Do the results fall within a plausible range?**                                                                                           | Using 2010 to 2014 NT AHKPI data, the range reported from PHC services for:  
- episodes of care: 314 to 892,202  
- clients contacts: 367 to 112,033                                                                                                                                                                                                                                                                                                                                                                                                     |
| **Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?** | This criterion requires comparison with other datasets which is not possible as part of this evaluation.  
This KPI won’t identify residents who seek care outside of the PHC service.  
If there are uncertainties surrounding the total number of residents in the community, the coverage rates will also be uncertain. This may be an issue in areas where there are transient groups.  
These limitations apply to all of the KPIs.                                                                                                                                                                                                                                                                                                                                                                                        |
| **Are all episodes of care and client contacts captured by the PHC service’s database?**                                                   | Systematic checks of the data are performed once the data reach the NT DoH warehouse. If the data do not meet the rules [outlined in the Data Receiving Protocol (DRP)] (S), the submission of the data fails and a violation report is sent to the AHKPI team who then contacts the PHC service to investigate the problem. Once the data are submitted (and meets the DRP rules) an initial report is generated, spot checked for errors and compared to previous reports at the NT DoH warehouse. If errors are picked up, the community health centre is requested to resubmit data and reports are re-generated and checked again.                                                                                                                                                                                                 |
| **Were the data correctly extracted by the NT DoH warehouse?**                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
When the reports are acceptable, they are sent out to the community health services once more to comment on data quality, if the communities pick up errors at this point here the communities are encouraged to contact the AHKPI team to arrange for re-submission of the data and the data would go through the same checking process again.

These system checks will not identify incomplete data (e.g. a resident who attends the service to be tested, screened and/or treated but who is not recorded into the system by the healthcare worker.

These system checks also won’t identify all incorrect data entries. They may pick up on obvious errors where the numerators and/or denominators fall outside of plausible ranges but they will not pick up on all errors. These systematic checks and limitations apply to all of the KPIs.

Although not applicable to this KPI, these system checks will not assess the variability of different testing devices used in different PHC services and whether these testing devices have been standardised regularly and/or stored appropriately. This limitation only applies to KPIs that require testing devices such as the HemoCue for the KPI 6 (proportion of children tested for anaemia and who are anaemic).

Were both numerators and denominators correct?

From 2009 to 2013, this indicator refers only to numerator data without any reference to denominators. It is not possible to determine whether the number of episodes of care, or client contacts are correct without cross referencing with other datasets. This limitation applies to all of the KPIs.
Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Have the data collection methods for measuring, calculating or recording this KPI changed over time?</th>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year</td>
<td>Month</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>Oct</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>March</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>Sept</td>
</tr>
</tbody>
</table>
disaggregated by:
  a. sex  
  b. age group  
  c. Indigenous status  
  d. residential status  
  e. locality
2. Client’s ages are calculated according to the date of the episode of care.
3. Client’s residential statuses are determined according to the date of the episode of care.

**Counting rules—Inclusions, exclusions**

a. Include episodes of care and client contact for both community residents and visitors and out-of-hours service contacts.

b. Excludes group contacts e.g. antenatal classes, men’s groups etc.

**To: Level/unit of counting**

1. Episode of care will be disaggregated by:
   a. sex
   b. age group
   c. Indigenous status
   d. residential status
   e. locality
2. Client’s ages are calculated according to the date of the episode of care.
3. Population ages are calculated according to the end of the reporting period.
4. Client’s residential statuses are determined according to the date of the episode of care.

**Counting rules—Inclusions, exclusions**

a. Include episodes of care and client contact for both community residents and visitors and out-of-hours service contacts.

b. Include live population count as at the end of the reporting period.

Excludes group contacts e.g. antenatal classes, men’s groups etc.’

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Change</th>
</tr>
</thead>
</table>
| 2014 | April | 2.0.4   | ‘Change: Add population denominator to allow for calculation of ratio of episodes of health care to population  
**Description:** Denominator segment to allow for health care provided ratio.**From:** Numerator |
### Episodic health care provided ratio

**Numerator**
- The number of episodes of health care during reporting period.
- The number of client contacts during reporting period.

**Denominator**
- The resident population count as at the end of the reporting period.

**Level/unit of counting**
1. Episode of care and population will be disaggregated by:
   - sex
   - age group
   - Indigenous status
   - residential status
   - locality
2. Client's ages are calculated according to the date of the episode of care.
3. Population ages are calculated according to the end of the reporting period.
4. Client's residential statuses are determined according to the date of the episode of care.

#### How complete are the data?

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Missing data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>-2 PHC services missing all data fields</td>
</tr>
<tr>
<td>2011</td>
<td>-1 PHC service missing all data fields</td>
</tr>
<tr>
<td>2012</td>
<td>-No missing data</td>
</tr>
<tr>
<td>2013</td>
<td>-No missing data</td>
</tr>
<tr>
<td>2014</td>
<td>-No missing data</td>
</tr>
</tbody>
</table>

#### Are the data collection and analysis methods documented in

Yes, all data collection methods and analysis methods are documented for all of the KPIs in ‘Northern Territory Aboriginal Health Key Performance Indicators System: Data Receiving Protocol, October 2014’.
Is there scientific evidence available to support the measure?  
This indicator monitors workload for a PHC service and can be used for PHC service planning and resource allocation. It does not measure the content or quality of the services provided.

---

**KPI 2 - ‘Timing of first antenatal visit for regular clients delivering Indigenous babies’**

**Rationale**

‘The aim of the antenatal care is to maximise the health outcomes of the mother and the baby. It aims to identify and manage risk factors or complications early, and to monitor progress with information and support during pregnancy’ (10).

**Definition**

‘The number and proportion of regular clients who are residents, who gave birth to Indigenous babies during reporting period and who attended first antenatal visit (at any health service locality) before 13 weeks’ gestation, disaggregated by age group, Indigenous status and locality. And the number and proportion of regular clients who are residents, who gave birth to Indigenous babies during reporting period and who attended first antenatal visit (at any health service locality) after 13 weeks (including 13 week) and before 20 weeks’ gestation, disaggregated by age group, Indigenous status and locality.

*Indigenous baby:*

*Indigenous baby is a baby with at least one parent who identifies as Indigenous (born to mothers who are either Indigenous or non-Indigenous)*

*First antenatal visit:*

*The guidelines of a ‘first antenatal visit’ are below:*

1. Blood Pressure test
2. Order mid-stream urine for microscopy, culture and sensitivities.
3. Order blood group and antibody test.’
## Importance of what is being measured

| What is the impact on health and on health expenditure? | There is an association between inadequate and late access to antenatal care services and increased risk of poor pregnancy outcomes such as stillbirths, perinatal deaths, foetal growth retardation, low birth weight and pre-term births (15). Between 30% and 50% of maternal deaths occur as a result of inadequate care during pregnancy (16). |
| Are policy makers and consumers concerned about the disease? | Yes. Antenatal care is an indicator in the National Indigenous Reform Agreement (17), with improved access to antenatal care being a focus of the agreement. Australian Governments are investing in a range of initiatives to improve access to antenatal care and preventive health practices (13). |
| Can the health care system meaningfully address this disease area problem? | Yes. Antenatal care is one of the core functions of Aboriginal Comprehensive Primary Health Care (3). Although there are challenges to delivery, the provision of physically accessible and culturally appropriate services, and the availability of transport influence whether pregnant women accesses antenatal care. Educational, socio-economic and financial issues also influence attendance (19, 20). An audit of antenatal services in Western Australia reported that 75% of services did not provide culturally appropriate models of care (21). This is an indicator of access to antenatal care which is influenced by not only the physical presence of PHC services but also the social conditions of the mother (22). |

## Scientific soundness

### Validity: are the data telling the truth?

| Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?) | This is an indicator that has been recommended and validated by EURO-PERISTAT through a standardised list of perinatal indicators developed by an expert panel (23). The goal of this panel is to develop valid and reliable indicators that can be used to monitor and evaluate perinatal health in the European Union (24). This indicator measures access to care but it does not provide any information on the content or quality of the antenatal care services. |
Standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.

<table>
<thead>
<tr>
<th>Do the results fall within a plausible range?</th>
<th>Yes. Using 2010 to 2014 NT AHKPI data the observed ranges were:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Antenatal visit &lt; 13 weeks = 1% to 98%</td>
</tr>
<tr>
<td></td>
<td>• Antenatal visit ≥ 13 weeks &lt; 20 weeks = 1% to 86%</td>
</tr>
<tr>
<td></td>
<td>• Antenatal visit ≥ 20 weeks = 1% to 93%</td>
</tr>
<tr>
<td></td>
<td>• Not recorded = 1% to 44%</td>
</tr>
<tr>
<td></td>
<td>• Did not visit = 1% to 35%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?</th>
<th>Are all pregnant mothers in the community captured at the PHC service?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This criterion requires comparison with other datasets which is not possible as part of this evaluation.</td>
</tr>
<tr>
<td></td>
<td>Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Were the data correctly extracted by the NT DoH warehouse?</th>
<th>Were both numerators and denominators correct?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes - all numerators and denominators fell into plausible ranges:</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
</tr>
<tr>
<td></td>
<td>2010</td>
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<tr>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>2013</td>
</tr>
<tr>
<td></td>
<td>2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Numerator:</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘The number of resident women aged: a. less than 20</td>
</tr>
<tr>
<td>b. 20-34 years</td>
</tr>
<tr>
<td>c. 35 years and over</td>
</tr>
<tr>
<td>and who attended first antenatal visit: a. before 13 weeks’ gestation b. at 13 weeks or after, but before 20 weeks c. at or after 20 weeks of pregnancy d. did not attend an antenatal visit e. not recorded whether attended an antenatal visit and who are: a. Indigenous b. non-Indigenous</td>
</tr>
</tbody>
</table>
and who gave birth to Indigenous babies during the reporting period.’

**Denominator:**
‘The number of resident women aged:
   a. less than 20
   b. 20-34 years
   c. 35 years and over

and who gave birth to an Indigenous baby during the reporting period.’

It is not mentioned what happens if a woman has an abortion or miscarriages.

**Reliability: does the measure provide stable results across various populations and circumstances?**

<table>
<thead>
<tr>
<th>Have the data collection methods for measuring, calculating or recording this KPI changed over time?</th>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year</td>
<td>Month</td>
</tr>
</tbody>
</table>
| | 2010 | Oct | 1.3.3 | Updated definition of a ‘first antenatal visit’ **from:**
| | | | - The definition of a ‘first antenatal visit’ is the clinical assessment according to the ‘Women’s Business Manual’ **to:**
| | | | - the date all three of the following tests are conducted:
| | | | 1. Blood Pressure Test
| | | | 2. Mid-stream urine for microscopy, culture and sensitives
| | | | 3. Order blood group and antibody test |
| | 2013 | March | 2.0.2 | Updated definition of a ‘first antenatal visit’ **from:**
| | | | - the date all three of the follow tests are conducted:
| | | | 1. Blood pressure test
| | | | 2. Mid-stream urine microscopy, culture and sensitivities
| | | | 3. Order blood group and antibody test **to:**
| | | | - the guidelines of a ‘first antenatal visit’ below:
| | | | 1. Blood Pressure Test |
| | 2013 | Sept | 2.0.3 |
### How complete are the data?

<table>
<thead>
<tr>
<th>Year</th>
<th>Missing data</th>
</tr>
</thead>
</table>
| 2010 | -4 PHC services missing all data fields  
              -No missing data for remaining PHC services  
              -Zero reporting not used for numerator data - unclear whether blank cells were omissions or intended to be a zero |
| 2011 | -3 PHC services missing all data fields  
              -No missing data for remaining PHC services  
              -Zero reporting not used for numerator data - unclear whether blank cells were omissions or intended to be a zero |
| 2012 | -0 PHC services missing all data fields  
              -Zero reporting not used for numerator data - unclear whether blank cells were omissions or intended to be a zero |
| 2013 | -2 PHC services missing all data fields  
              -No missing data for remaining PHC services  
              -Zero reporting not used for numerator data - unclear whether blank cells were omissions or intended to be a zero |
| 2014 | -2 PHC services missing all data fields  
              -No missing data for remaining PHC services  
              -Zero reporting not used for numerator data - unclear whether blank cells were omissions or intended to be a zero |

### Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?

Yes. See details under KPI 1.

### Is there scientific evidence available to support the measure?

This indicator is among those recommended by EURO-PERISTAT (25).
KPI 3 - ‘Number and proportion of low, normal and high birth weight Indigenous babies’

Rationale
The birth weight of an infant is a principle determinant of their chances of survival and good health. Low birth weight is a risk factor for neurological and physical anomalies, the risk of adverse outcomes increasing with decreasing birth weight. Low birth weight may be an indicator of inadequate foetal growth, resulting from pre-term birth or foetal growth restriction or both. Low birth weight is one of the major determinants of perinatal mortality. Infants weighing less than 2,500 grams are almost 40 times more likely to die within the first 28 days than of infants of normal birth weight.’

The Northern Territory has the highest incidence of low birth weight in Australia. Mothers less than 20 years old had the highest occurrence and the incidence of low birth weight babies amongst Indigenous mothers, almost twice the rate of non-Indigenous mothers’ (10).

Definition
The number and proportion of low, normal and high birth weight Indigenous babies who were live born during the reporting period and who were born to resident mothers, which are disaggregated by birth weight group, mother’s Indigenous status, mother’s age group and mother’s locality.

Indigenous baby
Indigenous baby is a baby with at least one parent who identifies as Indigenous (born to mothers who are both Indigenous or non-Indigenous)

Birth weight
Birth weight is the first weight of the baby obtained after birth (National Health Data Dictionary). Low, normal and high birth weights are less than 2,500 grams (World Health Organisation), between 2500 to 4499 grams, and 4500 grams and over respectively’ (10).

Importance of what is being measured

<table>
<thead>
<tr>
<th>What is the impact on health and on health expenditure?</th>
<th>Low birth weight increases an infant’s risk of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. dying during the first year of life</td>
</tr>
<tr>
<td></td>
<td>2. neurological and physical disabilities</td>
</tr>
<tr>
<td></td>
<td>3. developing a wide range of illnesses childhood and adulthood such as type 2 diabetes, high blood pressure and mortality from cardiovascular and renal diseases in adulthood and pulmonary causes in childhood (26, 27).</td>
</tr>
<tr>
<td></td>
<td>Low birth weight in babies is twice as common among babies born to Aboriginal and Torres Strait Islander mothers compared to those with non-Indigenous mothers (13% compared to 6%) (13).</td>
</tr>
<tr>
<td></td>
<td>The mean birth weight of newborn infants in a certain area is indicative of the quality of maternal and child health care services and the degree of socioeconomic development of that particular area (28).</td>
</tr>
</tbody>
</table>

Are policy makers and consumers concerned about the disease?
Yes - Australian governments have invested in a range of initiatives aimed at improving child health. In October 2008, COAG agreed to the National Partnership Agreement on
Indigenous Early Childhood Development with joint funding $564 million over six years. This includes:

1. Support for 85 New Directions: Mothers and Babies Services which provide ATSI families with access to antenatal care; practical advice and assistance with parenting, and health checks for children.
2. Health for Life programme which aims to improve access to antenatal, postnatal and child health care. This program aims to improve pregnancy, birth and child health outcomes (including birth weight) (13).

Can the health care system meaningfully address this disease area problem?

Yes, with targeted programmes:

1. Analysis of the perinatal dataset show that an increase in antenatal visits is associated with a decreased likelihood of low birth weight.
2. Research also shows that appropriate antenatal care and a health environment for the mother can improve the chances that a baby will have a healthy weight.
3. Improvements in health services such as antenatal and acute care for pregnant women are important to reduce the occurrence of pre-term delivery and to improve foetal growth during pregnancy.
4. Data from the Healthy for Life Program show that there has been a decline in the proportion of low birth weight Indigenous babies in the program and an increase in the number and proportion of Indigenous women who made an antenatal visit before 13 weeks of pregnancy.

Scientific soundness

Validity: are the data telling the truth?

Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)

The low birth weight rate is the most commonly used indicator to make comparisons across populations. However, this KPI has the following limitations:

1. Most infants in the NT are weighed at the hospital – information could be missing on the discharge summary or not all of the information could be getting transcribed from the discharge summary from the hospital to the PHC database.
2. the <2500g definition does not include small for gestational age and severely small for gestational age newborns, whose birth weight is between the 10th percentile and the 2500g threshold.
3. ‘2500g cut-off selects a very complex group of: a) Term small for gestational age and severely small for gestational age newborns (more than 2 or even 3 SD of...
the standard); b) Preterm small for gestational age and severely small for gestational age newborns; c) Preterm newborns that are appropriately grown for gestational age (AGA) with a lower perinatal risk, i.e. ‘late preterm’, and d) even a small group of Term AGA newborns. These four phenotypes have very different morbidity and mortality rates and long-term outcomes, requiring different preventive and therapeutic interventions. The relative contribution of each phenotype to the total incidence of low birth weight also varies according to the population, just as the contribution of multiple pregnancies (close to 15% of all low birth weight) varies according to these phenotypes’ (29).

<table>
<thead>
<tr>
<th>Do the results fall within a plausible range?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using 2010 to 2014 NT AHKPI data the range reported from PHC services for:</td>
</tr>
<tr>
<td>• Low birth weight babies = 0% to 100%</td>
</tr>
<tr>
<td>• Normal birth weight babies = 0% to 100%</td>
</tr>
<tr>
<td>• High birth = 0% to 100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are all Aboriginal and Torres Strait Islander babies in the community captured at the PHC service database?</td>
</tr>
<tr>
<td>This criterion requires comparison with other datasets which is not possible as part of this evaluation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Were the data correctly extracted by the NT DoH warehouse?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Were both numerators and denominators correct?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes - all numerators and denominators fell into plausible ranges:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>Yes</td>
</tr>
<tr>
<td>2012</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Reliability: does the measure provide stable results across various populations and circumstances?

Have the data collection methods for measuring, calculating or recording this KPI changed over time?

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Oct</td>
<td>1.3.3</td>
<td>‘Change: Specified period to include calendar year Calculation - Specified period From: Financial year To: Financial year or Calendar year.’</td>
</tr>
<tr>
<td>2013</td>
<td>March</td>
<td>2.0.2</td>
<td>No changes made</td>
</tr>
<tr>
<td>2013</td>
<td>Sept</td>
<td>2.0.3</td>
<td>No changes made</td>
</tr>
<tr>
<td>2014</td>
<td>April</td>
<td>2.0.4</td>
<td>No changes made</td>
</tr>
<tr>
<td>2014</td>
<td>Oct</td>
<td>2.0.7</td>
<td>No changes made</td>
</tr>
</tbody>
</table>

How complete are the data?

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Low birth weight</th>
<th>Missing data</th>
<th>Normal birth weight</th>
<th>High birth weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>-4 PHC services missing all data fields - blank numerator cells for 29 services - No missing data for remaining PHC services</td>
<td>-4 PHC services missing all data fields - blank numerator cells for 2 services - No missing data for remaining PHC services</td>
<td>-4 PHC services missing all data fields - blank numerator cells for 71 services</td>
<td>-4 PHC services missing all data fields - blank numerator cells for 67 services</td>
</tr>
<tr>
<td>2011</td>
<td>-2 PHC services missing all data fields - blank numerator cells for 35 services - No missing data for remaining PHC services</td>
<td>-2 PHC services missing all data fields - blank numerator cells for 2 services - No missing data for remaining PHC services</td>
<td>-2 PHC services missing all data fields - blank numerator cells for 67 services</td>
<td>-2 PHC services missing all data fields - blank numerator cells for 71 services</td>
</tr>
<tr>
<td>Year</td>
<td>Data Collection and Analysis Method Documentation</td>
<td>Scientific Evidence Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------</td>
<td>------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>0 PHC services missing all data fields - blank numerator cells for 41 services - No missing data for remaining PHC services</td>
<td>Yes. See details under KPI 1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>2 PHC services missing all data fields - blank numerator cells for 35 services - No missing data for remaining PHC services</td>
<td>Low birth weight is used as an indicator of child health internationally (30, 31).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>1 PHC service missing all data fields - blank numerator cells for 40 services - No missing data for remaining PHC services</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Chapter 3**

**KPI 4.1 - ‘Number and proportion of Indigenous children fully immunised at 1, 2 and 6 years of age’**

**Rationale**
‘Immunisation is a highly cost effective intervention in reducing morbidity and mortality rates in vaccine preventable diseases. Health system effectiveness in providing vaccination services can be measured by vaccination coverage at key milestones (12 and 24 months of age)’ (32).

**Definition**
‘Proportion of resident Indigenous children who are:
1. 6 months to less than 1 year
2. 1 year to less than 2 years
3. 2 years to less than 6 years.

_and who have received all age appropriate immunisations as per the NT immunisation schedule’ (10).

**Importance of what is being measured**

| What is the impact on health and on health expenditure? | Since the introduction of childhood vaccinations, deaths from vaccine-preventable diseases in Australia have fallen by 99%. It is estimated that vaccinations have saved approximately 78,000 lives (33) and have reduced the disparities in diseases between Indigenous and non-Indigenous populations (34). |
| Are policy makers and consumers concerned about the disease? | Yes. There are a range of Government funded immunisation programs:
- the National Immunisation Program (provides free childhood vaccines to eligible Australians);
- the National Human Papillomavirus (HPV) vaccination program.
The Australian Government has provided facilitation incentive payments to state and territory government through the National Partnership Agreement on Essential Vaccines (NPEV) since 2009 (13). |
| Can the health care system meaningfully address this disease area problem? | Yes, immunisations are one of the core functions of Aboriginal Comprehensive Primary Health Care (3). The level of immunisation coverage is reflective of the strength and effectiveness of primary health care (13). Vaccination coverage is generally high for Aboriginal and Torres Strait Islander children. In December 2013, the national vaccination coverage for Aboriginal and Torres Strait Islander children aged 1 year was 86%, 91.4% for children aged 2 years, and 92.8% for children aged 5 years, with the highest coverage rates reported in the NT (13). |
Scientific soundness

Validity: are the data telling the truth?

<table>
<thead>
<tr>
<th>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</th>
<th>Standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.</th>
</tr>
</thead>
</table>
| Do the results fall within a plausible range? | Using 2010 to 2014 NT AHKPI data the observed ranges were:  
- 6 months to < 1 year = 0% - 100%  
- 1 year to ≤ 2 years = 0% - 100%  
- 2 years to < 6 years = 0% - 100% |
| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting? | Are all children within the specified age groups in the community captured by the PHC service’s database?  
This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
<p>| Were the data correctly extracted by the NT DoH warehouse? | Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1. |
| Were both numerators and denominators correct? | Yes - all numerators and denominators fell into plausible ranges: |</p>
<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>Yes</td>
</tr>
<tr>
<td>2012</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Numerator:
1. The number of resident children aged 6 months to less than 1 year.
2. The number of resident children aged 1 year to less than 2 years.
3. The number of resident children aged 2 years to less than 6 years and who have received all age appropriate immunisations as per the NT immunisation schedule as at the end of
Denominator:
‘1. The number of resident children aged 6 months to less than 1 year.
2. The number of resident children aged 1 year to < 2 years.
3. The number of resident children aged 2 years to < 6 years as at the end of the reporting period.’

Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Oct</td>
<td>1.3.3</td>
<td>‘Change: specified period to include calendar year Calculation – Specified period From: Financial year To: Financial year or Calendar year.’</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>March</td>
<td>2.0.2</td>
<td>No changes made</td>
<td></td>
</tr>
</tbody>
</table>
| 2013 | Sept  | 2.0.3  | ‘Change: Update definition Description: Updated definition of fully immunised From: Proportion of resident Indigenous children who are:
1. 6 months to less than 1 year
2. 1 year to less than 2 years
3. 2 years to less than 6 years
and who are fully immunised according to the National Reporting Standard. To: Proportion of resident Indigenous children who are:
1. 6 months to less than 1 year
2. 1 year to less than 2 years
3. 2 years to less than 6 years
and who have received all age appropriate immunisations as per the NT immunisation schedule.’ | |
| 2014 | April | 2.0.4  | ‘Change: Re-number KPI Description: Renumber KPI 1.4 to 1.4.1 From: AHKPI 1.4 Fully immunised children To: AHKPI 1.4.1 Fully immunised Children.’ | |
| 2014 | Oct   | 2.0.7  | No changes made | |
### Are the data?

<table>
<thead>
<tr>
<th>Year</th>
<th>Missing data</th>
</tr>
</thead>
</table>
| 2010 | - 3 PHC services missing all data fields  
- Zero reporting not used so can’t be certain if there are missing data for 5 PHC services that have blank cells for  
- No missing data for remaining PHC services |
| 2011 | - 2 PHC services missing all data fields  
- Zero reporting not used so can’t be certain if there are missing data for 9 PHC services that have blank cells for  
- No missing data for remaining PHC services |
| 2012 | - Zero reporting not used so can’t be certain if there are missing data fields for 10 PHC services that have blank cells for  
- No missing data for remaining PHC services |
| 2013 | - Zero reporting not used so can’t be certain if there are missing data fields for 10 PHC services that have blank cells for  
- No missing data for remaining PHC services |
| 2014 | - Zero reporting not used so can’t be certain if there are missing data fields for 6 PHC services that have blank cells for  
- No missing data for remaining PHC services |

### Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?

Yes. See details under KPI 1.

### Is there scientific evidence available to support the measure?

It is an indicator used by the Australian Government to measure performance against the National Health Performance Framework (NHPF). There is a slight difference between the indicators however, with regard to the last age group category – the NT AHKPI reports for children aged 2 to < 6 years, whereas the NHPF indicator reports for children aged < 5 years (35).
KPI 4.2 - ‘Number and proportion of children who have received immunisations on time’

**Rationale:** ‘This indicator will assess immunisation timeliness in children less than twelve months using a more stringent definition of fully immunised than the existing NTAHF immunisation indicator. This indicator will thus provide additional information which will assist with improving immunisation timeliness in younger children who are at high risk of adverse outcomes from vaccine preventable diseases’ (10).

**Definition:** ‘Proportion of children between one and 12 months who have received all age appropriate immunisations on time’ (10).

**Importance of what is being measured**

| What is the impact on health and on health expenditure? | Delayed immunisations increase the risk for vaccine preventable diseases. Delayed immunisations and illness from vaccine-preventable disease is a significant problem for Aboriginal and Torres Strait Islander peoples (36-38). It’s a particular problem for infants in the first year of their life, putting them at risk of serious infections such as those caused by Haemophilus influenza and Streptococcus pneumoniae (39). The proportion of long delays among a cohort of Aboriginal and Torres Strait Islander children born in 2001 was 3 to 5 times higher in comparison to non-Indigenous children born during the same period across Australia (36). |
| Are policy makers and consumers concerned about the disease? | Yes. The Australian Government funds the National Immunisation Program which provides free childhood vaccinations. In addition to the vaccines provided as part of the standard vaccine schedule, the pneumococcal vaccine and the Hepatitis A vaccine are also provided free to Indigenous children living in high risk areas (40). |
| Can the health care system meaningfully address this disease area problem? | Little is known regarding the reasons for longer delays in Aboriginal and Torres Strait islander immunisations for children (39). However, factors causing delays in other populations include: socioeconomic disadvantage (41-43), coming from a large family, being a teenage or single parent, maternal smoking (44), poor understanding of the immunisation schedule (45), and the timeliness of the vaccine being outweighed by other more serious illnesses occurring in the child or in the family at the same time (46). The barriers specific to Aboriginal and Torres Strait Islander peoples will need to be explored if they are to be addressed successfully. However, timeliness can be improved by providing parents with reminders and offering opportunistic vaccinations when children attend health centres for any reason. |
**Scientific soundness**

**Validity: are the data telling the truth?**

<table>
<thead>
<tr>
<th>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</th>
<th>Standard uncertainties around numerator and denominator (people being seen outside of PHU, or not being entered into the system, or being incorrectly entered) are detailed under KPI 1.</th>
</tr>
</thead>
</table>
| Do the results fall within a plausible range? | Using 2013 to 2014 NT AHKPI data the range reported for the proportion of children who received immunisations on time from PHC services were:  
- 0% to 100% |
| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting? | This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
| Are all children 1 to 12 months of age in the community captured by the PHC service’s database? | Systematic checks of the data are carried out once the data reach the NT DoH warehouse. Please see detail of this and it limitations under KPI 1. |
| Were the data correctly extracted by the NT DoH warehouse? | Yes - all numerators and denominators fell into plausible ranges: |
| Were both numerators and denominators correct? | Year | Do numerators add up to denominator? |
| 2010 | N/A |
| 2011 | N/A |
| 2012 | N/A |
| 2013 | Yes |
| 2014 | Yes |

**Numerator:**

‘The number of resident children who are 1 month to less than 12 months of age and who have received all age appropriate immunisations on the NT Immunisation Schedule according to the counting rules set out below.’

**Denominator:**

‘The number of resident children who are 1 month to less than or equal to 12 months of age.’
Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Have the data collection methods for measuring, calculating or recording this KPI changed over time?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition version</strong></td>
</tr>
<tr>
<td>Year</td>
</tr>
<tr>
<td>2010</td>
</tr>
<tr>
<td>2013</td>
</tr>
<tr>
<td>2013</td>
</tr>
<tr>
<td>2014</td>
</tr>
<tr>
<td>2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How complete are the data?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calendar Year</strong></td>
</tr>
<tr>
<td>2010</td>
</tr>
<tr>
<td>2011</td>
</tr>
<tr>
<td>2012</td>
</tr>
</tbody>
</table>
| 2013 | - 2 PHC services missing all data fields  
- 3 empty numerator cells: unclear whether these were omissions or intended to be zeros  
- Zero reporting not used. We therefore cannot interpret the significance of these missing values  
- No missing data for remaining PHC services |
| 2014 | - 3 PHC services missing all data fields  
- 3 empty numerator cells: unclear whether these were omissions or intended to be zeros  
- Zero reporting not used. We therefore cannot interpret the significance of these missing values  
- No missing data for remaining PHC services |

| Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time? | Yes. See details under KPI 1. |

<table>
<thead>
<tr>
<th>Is there scientific evidence available to support the measure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immunisation is one of the most successful and cost-effective public health interventions (47). Reducing the number of delayed immunisations will reduce the risk for vaccine preventable diseases (36-38).</td>
</tr>
</tbody>
</table>
KPI 5 - ‘Number and proportion of children less than 5 years of age who are underweight’

**Rationale**
‘Weight for age is a sensitive measure of growth in children. The calculation does not require height so coverage is generally better than weight for height’ (10).

**Definition**
‘The number and proportion of children less than 5 years of age who are residents and who are less than -2 standard deviations away from the mean weight for age’ (10).

**Importance of what is being measured**

| What is the impact on health and on health expenditure? | This is an important indicator for monitoring the nutritional status of children. There is an increased risk of illness and mortality for children who are underweight (48). It is estimated that 45% of all deaths among children under five years of age is caused by malnutrition (49). |
| Are policy makers and consumers concerned about the disease? | Yes. In 1998 The Northern Territory (NT) Department of Health implemented a program called the Growth Assessment and Action (GAA) program (50) (now known as ‘The Healthy Kids under 5 Program’) which aims to monitor, promote, and improve growth of children aged zero to five years in remote communities of the NT (51). |
| Can the health care system meaningfully address this disease area problem? | Yes. ‘The Healthy Kids Under 5 Program’ program is one of the core functions of Aboriginal Comprehensive Primary Health Care in the NT (3). One of the key elements of this program is child health checks which allows for prevention, early detection, intervention and treatment (51). |

**Scientific soundness**

**Validity: are the data telling the truth?**

<table>
<thead>
<tr>
<th>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</th>
<th>Limitations to this indicator include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low weight for age can be reflective of either wasting (low weight for height) or stunting or both. Therefore, this indicator may be difficult to interpret. The United Nations state that the indicators: underweight, stunting, and wasting, should be analysed and presented together since they measure and reflect different features of child malnutrition (52), but this indicator only collects information on the proportion of children who are underweight.</td>
<td></td>
</tr>
</tbody>
</table>
Changes in a child’s body measurements can have multiple causes such as insufficient nutrient intake, stress, disease, infection, and genetic background and therefore interpretation and plans for how to meaningfully address any problems detected could be difficult (48).

Other standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.

| Do the results fall within a plausible range? | Using 2010 to 2014 NT AHKPI data, the range reported from health centres for:  
- the proportion of children weighed were 31% to 100%; and  
- the proportion of children underweight were 0% to 100%. |
| --- | --- |
| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting? | Are all children < 5 years in the community captured by the PHC service’s database?  
This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
| Were the data correctly extracted by the NT DoH warehouse? | Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1. |
| Were both numerators and denominators correct? | It is difficult to know if the numerators and the denominators were correct without cross referencing with other datasets but all numerators and denominators were within plausible ranges and no numerator exceeded the denominator.  
This assumes however that the scales used to measure the weight are tested and standardised regularly. |

The calculation includes underweight and coverage ratio:  
a. Underweight ratio: Number underweight/Number measured  
b. Coverage ratio: Number measured/Total population  
**Numerator:**  
- The number of resident children
who are less than 5 years of age at the date for weight measurement and who are more than -2 standard deviations away from the mean weigh for age during the reporting period.

b. The number of resident children less than 5 years of age at the date for weight measurement and who were measured for weight at least once during the reporting period.

Denominator:

c. The number of resident children who were less than five years of age at the beginning of the reporting period or were born during the reporting period and who were measured for weight at least once during the reporting period.

d. The number of resident children are less than 5 years of age at the beginning of the reporting period or were born during the reporting period.

Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Month</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>March</td>
<td>2.0.2</td>
<td>Removed all references to GAA data collection. ‘Data can also be sourced from the GAA Survey (Growth Assessment and Action) for most remote communities. Currently there are Annual GAA surveys in April. Data is collected at remote clinics and loaded into the DoH data warehouse. Calculations are applied to the raw data to produce statistical reports that are distributed to participating communities. Data validation is done for each survey round and data ‘out of range’ (&lt; -3 or &gt;3) are verified with the remote clinic before publication of the annual survey results. Data are from remote communities only. Not all communities participate in the survey at any given survey round and there have been approximately 80 communities who have ever participated. Approximately 60-65 communities participate in any survey round. Each clinic would need to provide population breakdown by age group/gender/Indigenous status and their data from GAA report.’</td>
</tr>
<tr>
<td>2013</td>
<td>Sept</td>
<td>2.0.3</td>
<td>No changes made.</td>
</tr>
<tr>
<td>2014</td>
<td>April</td>
<td>2.0.4</td>
<td>No changes made.</td>
</tr>
<tr>
<td>2014</td>
<td>Oct</td>
<td>2.0.7</td>
<td>No changes made.</td>
</tr>
</tbody>
</table>

### How complete are the data?

<table>
<thead>
<tr>
<th>Year</th>
<th>Missing data</th>
</tr>
</thead>
</table>
| 2010 | - 2 PHC services missing all data fields  
- 7 empty numerator cells: unclear whether this was an omission or intended to be a zero for the number of children underweight  
- No missing data for remaining PHC services |
| 2011 | - 5 PHC services missing all data fields  
- 6 empty numerator cells: unclear whether this was an omission or intended to be a zero for the number of children underweight  
- No missing data for remaining PHC services |
<table>
<thead>
<tr>
<th>Year</th>
<th>Observations</th>
</tr>
</thead>
</table>
| 2012 | - 0 PHC services missing all data fields  
- 22 empty numerator cells: unclear whether this was an omission or intended to be a zero for the number of children underweight  
- No missing data for remaining PHC services |
| 2013 | - 0 PHC services missing all data fields  
- 30 empty numerator cells where zeros should be for the number of children underweight: unclear whether this was an omission or intended to be a zero for the number of children underweight  
- No missing data for remaining PHC services |
| 2014 | - 0 PHC services missing all data fields  
- 30 empty numerator cells: unclear whether this was an omission or intended to be a zero for the number of children underweight  
- No missing data for remaining PHC services |

**Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?**

Yes. See details under KPI 1.

**Is there scientific evidence available to support the measure?**

Child growth is internationally recognized as an important indicator of nutritional status and health in populations (48).
KPI 6 - ‘Number and proportion of children between 6 months and 5 years of age who are anaemic’

**Rationale**
Haemoglobin levels are an indicator of the oxygen carrying capacity of the blood and are one indicator of nutritional status. Haemoglobin can be measured easily in the primary health care setting and results can be obtained instantly using a haemoglobinometer (10).

**Definition**
The number and proportion of children who are residents, who are:

- a. ≥ 6 months and < 12 months of age and whose haemoglobin level is less than 105 g/L, or
- b. ≥ 12 months and < 5 years of age and whose haemoglobin level is less than 110 g/L

(53)

**Importance of what is being measured**

| What is the impact on health and on health expenditure? | Anaemia has adverse effects on many areas of child health including cognitive, behavioural and physical development, as well as immune function (54-56). Children with iron deficiency anaemia (IDA) in infancy are more likely to fail to complete secondary school, be single, and have negative emotions (57). If anaemia or IDA is left untreated, developmental delays can persist into adulthood impacting work and economic productivity (58). The World Health Organisation (WHO) considers anaemia as a public health problem when the prevalence of anaemia is > 5% (55). |
| Are policy makers and consumers concerned about the disease? | Yes. In 1998 The Northern Territory (NT) Department of Health implemented a program called the Growth Assessment and Action (GAA) program (50) (now known as ‘The Healthy Kids under 5 Program’) which aims to monitor, promote, and improve growth of children aged zero to five years in remote communities of the NT (51) and childhood anaemia is monitored as part of this program. |
| Can the health care system meaningfully address this disease area problem? | Yes. ‘The Healthy Kids Under 5 Program’ program is one of the core functions of Aboriginal Comprehensive Primary Health Care in the NT (3). One of the key elements of this program is child health checks which allows for prevention, early detection, intervention and treatment (51). Depending on the Haemoglobin (Hb) levels of the child, anaemia in the NT is treated with iron, albendazole (if they live in the Top End of the NT). If a child’s Hb is < 90g/L folate is given and a full blood test is requested. The Central Australian Rural Practitioners Association manual recommends that all anaemic children (regardless of Hb levels) should be followed up (53). |
Scientific soundness

Validity: are the data telling the truth?

<table>
<thead>
<tr>
<th>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</th>
<th>Limitations with this indicator include:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anaemia has many potential causes (59, 60). This indicator does not provide information on what the causes of anaemia may be. For example measuring levels of Hb does not indicate iron deficiency anaemia; this is measured using serum ferritin which requires a full blood examination (53).</td>
</tr>
<tr>
<td></td>
<td>Currently the HemoCue haemoglobinometer is used in the NT to screen for anaemia (61). It’s reported to have good sensitivity (85%) and specificity (94%) in detecting anaemia (62, 63). The sensitivity is reported to reach 100% in controlled laboratory conditions (64). However, the reproducibility, accuracy and precision of the HemoCue results are highly dependent on the conditions under which the test has been conducted, whether venous or capillary blood has been collected and whether the HemoCue products have been stored in appropriate storage conditions, particularly in humid climates (65, 66).</td>
</tr>
<tr>
<td>Children tested for anaemia outside of the local PHC will not be captured as part of this KPI.</td>
<td></td>
</tr>
<tr>
<td>This KPI relies on the correct information being entered into the electronic database. If a child is tested but is not entered into the system, they will not be captured as part of this KPI. If a child is tested, and the Hb results are entered incorrectly into the system this will not reflect the truth.</td>
<td></td>
</tr>
<tr>
<td>If there are uncertainties surrounding the total number of resident children between 6 months and 5 years residing in the community, it can make it difficult to estimate the accurate coverage of children tested for anaemia. This may be an issue for areas where there are transient groups.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Do the results fall within a plausible range?</th>
<th>Using 2010 to 2014 NT AHKPI data, the range reported from health centres for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>the proportion of children tested were 10% to 100%; and</td>
</tr>
<tr>
<td></td>
<td>the proportion of children anaemic were 0% to 72%.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of)</th>
<th>Are all children aged between 6 month and &lt; 5 years in the</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This criterion requires comparison with other datasets which is not possible as part of this evaluation.</td>
</tr>
</tbody>
</table>
aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?

| Was the calculation performed correctly? | The calculation includes anaemic ratio and coverage ratio:  
1. **Anaemic Ratio:** Number Anaemic/Number Measured  
2. **Coverage Ratio:** Number Measured/Total Population |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Were the data correctly extracted by the NT DoH warehouse?</td>
<td>Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1.</td>
</tr>
<tr>
<td>Were both numerators and denominators correct?</td>
<td>It is difficult to know if the numerators and the denominators were correct without cross referencing with other datasets but all numerators and denominators were within plausible ranges and no numerator exceeded the denominator.</td>
</tr>
</tbody>
</table>

**Numerator:**

1. *The number of resident children, who are:*
   
a. ≥ 6 months and < 12 months of age at the date for anaemia measurement and whose Hb level is < 105 g/L during the reporting period.
   
or
   b. > 12 months and < 5 years of age at the date for anaemia measurement and whose Hb level is < 110 g/L during the reporting period.

2. *The number of children who are residents and who are ≥ 6 months and < 5 years of age and who have been measured for anaemia during the reporting period.*

*Child’s ages are calculated according to the date for anaemia measurement.*
Denominator:

1. The number of resident children who are ≥ 6 months and < 5 years of age at the beginning of the reporting period or were born during the first six months of the reporting period and who have been measured for anaemia during the reporting period.

2. The number of resident children who are ≥ 6 months and < 5 years of age at the beginning of the reporting period or were born during the first six months of the reporting period.

*Child’s ages are calculated to the end of reporting period to include those who are less than six years of age. (E.g. includes all children who were < 5 years of age at the beginning of the reporting period or were born during the first 6 months of the reporting period.)*

Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Oct</td>
<td>1.3.3</td>
<td>‘Change: Align anaemia cut off to revised CARPA definition.</td>
</tr>
</tbody>
</table>

**Definition**

**From:** The number and proportion of children who are residents, who are ≥ 6 months and < 5 years of age and whose haemoglobin level is < 110 g/L (WHO definition).

**To:** The number and proportion of children who are residents, who are:

- a. ≥ 6 months and < 12 months of age and whose haemoglobin level is less than 105 g/L
- or
- b. ≥ 12 months and < 5 years of age and whose haemoglobin level is less than 110 g/L

Calculation – Numerator
From:
1. The number of children who are residents, who are ≥ 6 months and < 5 years of age and whose haemoglobin level is < 110 g/L (WHO definition) during the reporting period.
2. The number of children who are residents, who are ≥ 6 months and < 5 years of age and who have been measured for anaemia during the reporting period.

To:
1. The number of children who are residents, who are:
   a. ≥ 6 months and < 12 months of age and whose haemoglobin level is less than 105 g/L or
   b. ≥ 12 months and < 5 years of age and whose haemoglobin level is less than 110 g/L during the reporting period.
2. The number of children who are residents, who are:
   a. ≥6 months and < 5 years of age and who have been measured for anaemia during the reporting period.

Calculation - Denominator
From:
1. The number of children who are residents, who are ≥ 6 months and < 5 years of age and who have been measured for anaemia during the reporting period.
2. The number of children who are residents, who are ≥ 6 months and < 5 years of age during the reporting period.

To:
1. The number of children who are residents, who are:
   a. ≥ 6 months and < 5 years of age and who have been measured for anaemia during the reporting period
2. The number of children who are residents, who are:
   a. ≥6 months and < 5 years of age during the reporting period.

Sound methodology
From: Methodology is based on WHO definitions
To: Methodology is based on CARPA definitions
Change: Specified period to include calendar year
<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>March</td>
<td>2.0.2</td>
<td>'Change: Data Quality and Availability. Description: Removed all references to GAA data collection. Data are provided to most remote communities from the GAA Survey (Growth Assessment and Action). Currently there are Annual GAA surveys in April. Data are collected at remote clinics and loaded into the DoH data warehouse. Calculations are applied to the raw data to produce statistical reports that are distributed to participating communities. Data validation is done for each survey round and data 'out of range' (&lt; -3 or &gt;3) are verified with the remote clinic before publication of the annual survey results. Data is from remote communities only. Not all communities participate in the survey at any given survey round and there have been approximately 80 communities who have ever participated. Approximately 60-65 communities participate in any survey round.'</td>
</tr>
<tr>
<td>2013</td>
<td>Sept</td>
<td>2.0.3</td>
<td>No changes made.</td>
</tr>
<tr>
<td>2014</td>
<td>April</td>
<td>2.0.4</td>
<td>No changes made.</td>
</tr>
<tr>
<td>2014</td>
<td>Oct</td>
<td>2.0.7</td>
<td>'Change: Update to include disaggregation by age group. Description: To give further breakdown of anaemia by age groups, 6-12 months, 12-24 months and 24-60 months. From: Level/unit of counting: Disaggregated by: a. locality b. Indigenous status. To: Level/unit of counting: Disaggregated by: a. locality b. Indigenous status c. Age groups.'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Missing data</th>
</tr>
</thead>
</table>
| 2010     | - 2 PHC services missing all data fields  
- 1 empty numerator cell: unclear whether this was an omission or intended to be a zero for the number of children tested for anaemia (Zero reporting had been used for this KPI)  
- No missing data for remaining PHC services |
<p>| 2011     | - 5 PHC services missing all data fields |</p>
<table>
<thead>
<tr>
<th>Year</th>
<th>Details</th>
</tr>
</thead>
</table>
| 2012 | - No missing data for remaining PHC services  
- 0 PHC services missing all data fields  
- 2 empty numerator cells: unclear whether this was an omission or intended to be a zero for the number of children tested for anaemia (Zero reporting had been used for this KPI)  
- No missing data for remaining PHC services |
| 2013 | - 0 PHC services missing all data fields  
- 7 empty numerator cells: unclear whether this was an omission or intended to be a zero for the number of children tested for anaemia (Zero reporting had been used for this KPI)  
- No missing data for remaining PHC services |
| 2014 | - 0 PHC services missing all data fields  
- 3 empty numerator cells: unclear whether this was an omission or intended to be a zero for the number of children tested for anaemia (Zero reporting had been used for this KPI)  
- No missing data for remaining PHC services |

Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?

Yes. See details under KPI 1.

Is there scientific evidence available to support the measure?

Measuring an individual’s Hb (the iron-carrying component of red blood cells) is the most convenient and common way of detecting anaemia (63, 64) and is recommended by the WHO (60).

The Hb cut off for children aged ≥ 6 and < 12 months differs from the WHO definition. The authors of CARPA argue that reference values for normal Hb levels for children in this age group are not well established and are extrapolated from an older population (67). As a result they have decided to use a lower the cut off to < 105 g/L for this age group based on two studies (68, 69) to reduce the number of iron injections and their potential side effects to this cohort of children who may not need it (67).
KPI 7 - ‘Number and proportion of resident clients aged 15 years and over with Type II Diabetes and/or Coronary Heart Disease who have a chronic disease management plan’

Rationale
‘Preventable chronic diseases are responsible for a significant burden of disease for Aboriginal people and if poorly controlled increase hospitalisations, complications and the cost of healthcare. Care plans are the foundation for providing appropriate long-term care and an increase in the proportion will demonstrate improved health service delivery’ (10).

Definition
‘The number and proportion of resident Indigenous clients, who are 15 years old and over, who have been diagnosed with Type II diabetes and/or Coronary Heart disease and who have a valid Chronic Disease Management Plan at the end of reporting period.

Coronary Heart Disease (also referred to as Ischemic Heart Disease):
Based on NPCC Guidelines Coronary Heart Disease includes:
1. Myocardial infarction
2. Angina
3. Unstable angina pectoris
4. Revascularisation as evidenced by angioplasty with or without a stent
5. Coronary artery bypass surgery

CHD’s primary feature is insufficient blood supply to the heart itself. The two major clinical forms are heart attack (the insufficient blood supply is sudden and extreme) and angina.

Type II diabetes:
Type II diabetes includes the common major form of diabetes, which results from defect(s) in insulin secretion, almost always with a major contribution from insulin resistance. Type II diabetes does not include: Type I diabetes, Gestational diabetes mellitus, Secondary diabetes, impaired fasting glycaemia or impaired glucose tolerance.

Chronic Disease Management Plan:
Chronic Disease Management Plans for the purpose of this indicator are defined as:
1. MBS item 721 - General Practitioner Management Plan (GPMP), (Medicare Benefit Schedule) (Item 721 and 723) (Medicare Australia 2007) or
2. Alternative Chronic Disease Management Plan in the form of General Practitioner (or equivalent) Management Plan that cannot be claimed that includes the following items in clinical guidelines and protocols for developing an alternative GPMP.

The following mandatory items are included in the alternative General Practitioner Management Plan:
   a) Assessing the patient to identify and/or confirm the entire patients health care needs, problems and relevant conditions
b) Agreeing management goals with the patient for the changes to be achieved by the treatment and services identified in the plan

c) Identifying any actions to be taken by the patient

d) Identifying treatment and services that the patient is likely to need and making arrangements for provision of these services and ongoing management

e) Documenting the patient’s needs, goals, patient actions, treatment/services and a review date i.e. completing the GPMP document

3. MBS Item 723 - Chronic Disease Management Plan Team Care Arrangements (TCA),

f) (Medicare Benefit Schedule) (Item 721 and 723) (Medicare Australia 2007) or

4. Alternative Chronic Disease Management Plan in the form of TCA’s that includes the following items in clinical guidelines and protocols for developing an alternative TCA.

The following mandatory items are included in the alternative Team Care Arrangement:

a) Discussing with the patient which treatment/service providers should be asked to

b) Gaining the patient’s agreement to share relevant information about their medical history, diagnoses, GPMP etc. (with or without restrictions) with the proposed providers;

c) Contacting the proposed providers and obtaining their agreement to participate, realising that they may wish to see the patient before they provide input but that they may decide to proceed after considering relevant documentation, including any current GPMP;

d) Collaborating with the participating providers to discuss potential treatment/services they will provide to achieve management goals for the patient;

e) Documenting the goals, the collaborating providers, the treatment/services they have agreed to provide, any actions to be taken by the patient and a review date i.e. completing the TCA document; and

f) Providing the relevant parts of the TCA to the collaborating providers and to any other persons who, under the TCA, will give the patient the treatment/services mentioned in the TCA.’

Numerator(s):

‘Chronic Disease Management Plan (MBS Item 721 – General Practitioner Management Plan - 2 year reporting period)

The number of resident clients who are aged 15 years and over and who have been diagnosed with:

a. Type II diabetes

b. Coronary heart disease

c. Type II diabetes & coronary heart disease, and who have a current MBS item 721 Chronic Disease Management Plan that was initiated within the previous 2 reporting periods. A current MBS item 721 Chronic Disease Management Plan is valid for two years. Therefore, all clients with a current and valid MBS item 721 Chronic Disease Management Plan at the end of the reporting period should be included in the count for this numerator, not just those who received a MBS item 721 Chronic Disease Management Plan within the reporting period.

Chronic Disease Management Plan (MBS Item 721 – General Practitioner Management Plan - 1 year reporting period)
The number of resident clients who are aged 15 years and over and who have been diagnosed with:

a. Type II diabetes  
b. Coronary heart disease  
c. Type II diabetes & coronary heart disease, and who have a current MBS item 721 Chronic Disease Management Plan that was initiated within the previous reporting period.

**Alternative Chronic Disease Management Plan (Alternative General Practitioner Management Plan – 2 year reporting period)**  
The number of resident clients who are aged 15 years and over and who have been diagnosed with:  
a. Type II diabetes  
b. Coronary heart disease  
c. Type II diabetes & coronary heart disease, and who have an alternative Chronic Disease Management Plan in the form of a General Practitioner Management Plan that was initiated within the previous 2 reporting periods. A current alternative Chronic Disease Management Plan is valid for two years. Therefore, all clients with a current/valid management plan at the end of the reporting period should be included in the count, not just those who received a management plan within the reporting period.

**Chronic Disease Management Plan (MBS Item 723 - Team Care Arrangements – 2 year reporting period)**  
The number of resident clients who are 15 years of age and over and who have been diagnosed with:  
a. Type II diabetes  
b. Coronary Heart Disease  
c. Type II diabetes & coronary heart disease and who have a current MBS item 723 Chronic Disease Management Plan Team Care Arrangement that was initiated within the previous 2 reporting periods. A current MBS item 723 Team Care Arrangement is valid for two years. Therefore, all clients with a current/valid Team Care Arrangement at the end of the reporting period should be included in the count, not just those who received a Team Care Arrangement plan within the reporting period.

**Chronic Disease Management Plan (MBS Item 723 - Team Care Arrangements – 1 year reporting period)**  
The number of resident clients who are 15 years of age and over and who have been diagnosed with:  
a. Type II diabetes  
b. Coronary Heart Disease  
c. Type II diabetes & coronary heart disease, and who have a current MBS item 723 Chronic Disease Management Plan Team Care Arrangement that was initiated within the previous reporting period.

**Alternative Chronic Disease Management Plan (Alternative Team Care Arrangements – 2 year reporting period)**
The number of resident clients who are aged 15 years and over and who have been diagnosed with:

a. Type II diabetes
b. Coronary heart disease
c. Type II diabetes & coronary heart disease, and who have an alternative Chronic Disease Management Plan Team Care Arrangement in the form of a General Practitioner Management Plan, Team Care Arrangement that was initiated within the previous 2 reporting periods. A current alternative Team Care Arrangement is valid for two years. Therefore, all clients with a current/valid Team Care Arrangement at the end of the reporting period should be included in the count, not just those who received a Team Care Arrangement plan within the reporting period.

Alternative Chronic Disease Management Plan (Alternative Team Care Arrangements – 1 year reporting period)
The number of resident clients who are aged 15 years and over and who have been diagnosed with:

a. Type II diabetes
b. Coronary heart disease
c. Type II diabetes & coronary heart disease, and who have an alternative Chronic Disease Management Plan Team Care Arrangement in the form of a General Practitioner Management Plan, Team Care Arrangement that was initiated within the previous reporting period.

Alternative Chronic Disease Management plan (Alternative General Practitioner Management Plan – 1 year period)
The number of resident clients who are aged 15 years and over and who have been diagnosed with:

a. Type II diabetes
b. Coronary heart disease
c. Type II diabetes & coronary heart disease, and who have an alternative Chronic Disease Management Plan in the form of a General Practitioner Management Plan that was initiated within the previous reporting period.

Denominator (for MBS Item 721, 723 and Alternative GPMP & TCA Care Plans)
The number of resident clients who are aged 15 years and over and who have been diagnosed with:

a. Type II diabetes
b. Coronary heart disease.
c. Type II diabetes & coronary heart disease’ (10).
### Importance of what is being measured

| **What is the impact on health and on health expenditure?** | Chronic disease is estimated to contribute to 70% of the health gap between Aboriginal and Torres Strait Islanders and non-Indigenous Australians (70).

Cardiovascular disease (CVD) was the leading cause of death for Indigenous Australians in 2008-2012. It accounts for 25% of deaths in Indigenous Australian and for 24% of the gap in death rates between Indigenous and non-Indigenous Australians (71). The age adjusted rate for CVD is nearly twice as high in Indigenous Australians compared to non-Indigenous Australians (71). Indigenous people are more likely to die from CVD when they are young or in their middle age compared to non-Indigenous Australians (72).

Type 2 diabetes was the second leading specific cause of death for Indigenous Australians, accounting for 8% of deaths (71). In 2012-2013, the age adjusted rate for developing type 2 diabetes in Indigenous Australians was three times higher in Indigenous Australians compared to non-Indigenous Australians and onset of disease occurs at a younger age (13). Around 45% of Indigenous Australians aged ≥ 15 years who reported having diabetes also reported having a circulatory disease (73). |
| **Are policy makers and consumers concerned about the disease?** | Yes, diabetes and CVD are in the ‘2014 Aboriginal and Torres Strait Islander Health Performance Framework’ (13). There are a range of Government initiatives for both diseases such as:

1. The Diabetes Care Project pilot - tests new models of healthcare arrangements for people with Type 1 and 2 diabetes.
2. The Indigenous Australians Health programme - provides diabetes prevention and management through comprehensive primary health care (diabetes and CVD).
3. The national recommendations for the better cardiac care for Aboriginal and Torres Strait Islander people.
4. The Australian Government-funded essential service standards (ESSENCE) project - identifies areas of care that needed to reduce the disparity in access and outcomes for circulatory disease. |
### Can the health care system meaningfully address this disease area problem?

Lighthouse project – aims to change the acute care sector to improve care and outcomes for Indigenous Australians with CVD (13).

Culturally appropriate, family centred approaches, engagement with communities and working collaboratively across the continuum of care and prevention are needed for primary health care to be successful in addressing these disease areas (74).

Other strategies to address the challenges in this disease area included: good disease management guidelines, support to address local factors, appropriate staffing and training polices, defined roles for practitioners and education and health promotion in the community with strong community engagement (75).

### Scientific soundness

#### Validity: are the data telling the truth?

<table>
<thead>
<tr>
<th>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</th>
<th>Limitations with this indicator include: This indicator measures how many resident clients (who need it) have a chronic disease management plan. It does not measure what the total care is or whether the quality of the care provided is appropriate and effective for individual needs. MBS (Medicare Benefit Schedule) items are not claimed by all organisations because the service may not be eligible to claim, there may not be a general practitioner present to make the claim, or services may not be completing the reporting in a way that meets the requirements for MBS billing (AIHW). Other standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.</th>
</tr>
</thead>
</table>
| Do the results fall within a plausible range? | Using 2010 to 2014 NT AHKPI data, the range reported from health centres for:  
  - Chronic disease management plan = 0% to 128% (108% for one PHC in 2010 and 128% for one PHC in 2011)  
  - Alternative team arrangement plan = 0% to 99%  
  This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not | Are resident clients’ ≥ 15 years with Type II Diabetes and/or Coronary Heart Disease in the community |

3-65
produce consistently over-counting or under-counting? | captured by the PHC service’s database?
---|---
Were the data correctly extracted by the NT DoH warehouse? | Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and its limitations in KPI 1.
Were both numerators and denominators correct? | No, for one service the numerators exceeded the denominators giving a total proportion of resident clients on a chronic disease management plan for one service being 108% in 2010 and 128% in 2011. For the remaining years and services, yes - all numerators and denominators fell into plausible ranges:

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>No</td>
</tr>
<tr>
<td>2011</td>
<td>No</td>
</tr>
<tr>
<td>2012</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Have the data collection methods for measuring, calculating or recording this KPI changed over time?</th>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Month</td>
<td>Version</td>
</tr>
<tr>
<td>2010</td>
<td>Oct</td>
<td>1.3.3</td>
</tr>
</tbody>
</table>
PCIS, the data required to calculate this performance indicator will be extracted directly from their database.'

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Change</th>
<th>Description</th>
</tr>
</thead>
</table>
| 2013 | March | 2.0.2  | **Change: Calculation**  
**Description:** Consolidated denominator definition for MBS item 721, 723 & Alternative.  
**From denominator:** Denominator for MBS Item 721 and Alternative  
The number of Indigenous adults who are:  
1. Male  
2. Female  
Who were aged:  
a) 15-24 years  
b) 25-44 years  
c) 45-64 years  
d) 65 years and over  
Who are regular clients of the service that have been diagnosed with:  
1. Type II Diabetes  
2. Coronary Heart Disease  
**To:** Denominator for MBS Item 723 and Alternative  
The number of Indigenous adults who are:  
1. Male  
2. Female  
Who were aged:  
a) 15-24 years  
b) 25-44 years  
c) 45-64 years  
d) 65 years and over  
Who are regular clients of the service that have been diagnosed with:  
i) Type II Diabetes  
ii) Coronary Heart Disease  
**Change: Counting rules**  
**Description:** Update the counting rules to reflect a distinct count of clients for the
Chapter 3

<table>
<thead>
<tr>
<th>Year</th>
<th>Reporting period</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>To</td>
</tr>
<tr>
<td>From:</td>
<td>Financial year or Calendar year.</td>
</tr>
<tr>
<td>To:</td>
<td>1. Collect data every financial year or calendar year for the previous year</td>
</tr>
</tbody>
</table>
|      | 2. Collect data every financial year or calendar year for the previous 2 years.

### How complete are the data?

<table>
<thead>
<tr>
<th>Year</th>
<th>Missing data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>- 1 PHC service missing all data fields (including numerator and denominator)</td>
</tr>
<tr>
<td></td>
<td>- Zero reporting not used. We therefore cannot interpret the significance of a missing value for all 84 services</td>
</tr>
<tr>
<td>2011</td>
<td>- 1 PHC service missing all data fields (including numerator and denominator)</td>
</tr>
<tr>
<td></td>
<td>- Zero reporting not used. We therefore cannot interpret the significance of a missing value for all 84 services</td>
</tr>
<tr>
<td>2012</td>
<td>- 0 PHC services missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- Zero reporting not used. We therefore cannot interpret the significance of a missing value for all 84 services</td>
</tr>
<tr>
<td>2013</td>
<td>- 0 PHC service missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- Zero reporting not used. We therefore cannot interpret the significance of a missing value for all 84 services</td>
</tr>
<tr>
<td>2014</td>
<td>- 0 PHC service missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- Zero reporting not used. We therefore cannot interpret the significance of a missing value for all 84 services</td>
</tr>
</tbody>
</table>

**Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?**

Yes. See details under KPI 1.

**Is there scientific evidence available to support the measure?**

Treatment and management of chronic disease requires long-term planned chronic disease programs (76). Organised management of chronic diseases at the primary health care level can delay progression of disease and lead to improved health outcomes (77-81).
KPI 8.1 - ‘Number and proportion of resident clients aged 15 years and over with Type II Diabetes who have had an HbA1c measurement result recorded’

Rationale:
‘Glycosylated haemoglobin (HbA1c) is an index of average blood glucose level for the previous 2 to 3 months and is used to monitor blood sugar control in diabetic people. It is a marker of the increased risk of developing atherosclerosis, myocardial infarction, strokes, cataracts and loss of the elasticity of arteries, joints and lungs. The US Diabetes Control and Complications Trial and the UK Prospective Diabetes Study have established that the risk of diabetic complications is strongly associated with previous hyperglycaemia and that any reduction in HbA1c is likely to reduce the risk of complications.’

Definition:
‘The number and proportion of regular clients who are residents, who are 15 years old and over, who have been diagnosed with Type II diabetes and who have had an HbA1c measurement result recorded within the previous 6 months AND regular clients who are residents, who are 15 years old and over, who have been diagnosed with Type II diabetes and who have had an HbA1c measurement result recorded within the previous 12 months, which are disaggregated by gender by age group by locality’ (10).

Importance of what is being measured

| What is the impact on health and on health expenditure? | Type 2 diabetes was the second leading specific cause of death for Indigenous Australians, accounting for 8% of deaths (71). The age adjusted prevalence for type 2 diabetes in Indigenous Australians was three times higher Indigenous Australians in 2012-2013 compared to non-Indigenous Australians and starts at a younger age (13).

Poorly-controlled blood glucose in diabetics increases the risk of overall mortality (82) and diabetic complications such as gangrene that requires amputation (83), end stage kidney disease (84), and eye disease, particularly diabetic retinopathy (85). Indigenous Australians with type 2 diabetes have a ten-fold greater risk of kidney failure due to diabetes compared to non-Indigenous Australians (86). Early identification of poorly controlled blood sugar with the high HbA1c levels allows for improved treatment to delay or prevent complications. |
| Are policy makers and consumers concerned about the disease? | Yes diabetes is in the ‘2014 Aboriginal and Torres Strait Islander Health Performance Framework’ (13). The Australian Government has funded the following initiatives:
1. The Diabetes Care Project pilot that tests new models of healthcare arrangements for people with type 1 and type 2 diabetes.
2. The Indigenous Australians Health programme - provides diabetes prevention and management |
through comprehensive primary health care
General practitioner health assessments for Indigenous Australians under the Medical Benefits Scheme. These health assessments include follow-on care and incentive payments for improved management, and cheaper medicines through the Pharmaceutical Benefits Scheme (13).

Can the health care system meaningfully address this disease area problem?

Yes, but a multidisciplinary (including social and/or mental health professionals), culturally appropriate approach (13) with targeted education of patients are key to successful programs (87).

Scientific soundness

Validity: are the data telling the truth?

Limitations with this indicator include:
Even though HbA1c is the gold standard indicator for glycaemic control, there are a range of other conditions which can affect the normal life cycle of erythrocytes and therefore the HbA1c results. For example, in individuals with haemolytic anaemia, the average life of an erythrocyte is abnormally shorter; this results in a lower HbA1c levels, regardless of glycaemia. Conversely, in individuals with aplastic anaemia, the age of the erythrocytes are older, resulting in higher HbA1c levels regardless of glycaemia (88). There are a range of other conditions such as genetic conditions, vitamin B deficiencies, use of certain medications and alcoholism which can also affect the HbA1c levels independent of glycaemia (89).

It is not known whether different point of care devices are used to test for HbA1c levels at different PHC services throughout the NT, which would results in variations in sensitivity and specificity of the results across the NT. Different storage conditions, would also have an effect on the sensitivity and/or specificity of the testing device. Other standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.

Using 2010 to 2014 NT AHKPI data the range reported from PHC services were:
• 6% to 100%

Are type 2 diabetics in the community captured by the
This criterion requires comparison with other datasets which is not possible as part of this evaluation.
aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?

Were the data correctly extracted by the NT DoH warehouse?

Were both numerators and denominators correct?

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>Yes</td>
</tr>
<tr>
<td>2012</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

PHC service’s database?

Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1. Specific to this KPI, these systems do not assess the possible variation between different HbA1c devices used through the NT or whether these devices are tested and standardised regularly.

Numerator:
‘The number of resident clients who are aged 15 years and over who have been diagnosed with type II diabetes, and who have had one or more HbA1c tests (If a client has more than one HbA1c test during reporting period, counts the last one only).’

Denominator:
‘The number of resident clients who are aged 15 years and over and who have been diagnosed with type II diabetes.’
Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Month</td>
</tr>
<tr>
<td>2010</td>
<td>Oct</td>
</tr>
<tr>
<td>2013</td>
<td>March</td>
</tr>
<tr>
<td>2013</td>
<td>Sept</td>
</tr>
<tr>
<td>2014</td>
<td>April</td>
</tr>
<tr>
<td>2014</td>
<td>Oct</td>
</tr>
</tbody>
</table>
periods, 6 month and 12 month.

Description: Addition of a 12-month reporting period to the KPI to allow data comparison between KPI 1.8.1 and KPI 1.8.2.

From: Indicator: 8.1 Number and proportion of resident clients aged 15 years and over with Type II Diabetes who have had an HbA1c test in the last 6 months

To: Indicator: 8.1 Number and proportion of resident clients aged 15 years and over with Type II Diabetes who have had an HbA1c measurement result recorded

From: Definition: The number and proportion of Indigenous and non-Indigenous clients who are residents, who are 15 years old and over, who have been diagnosed with Type II diabetes and who have had an HbA1c test during reporting period, which are disaggregated by gender by age group by locality.

To: Definition: The number and proportion of regular clients who are residents, who are 15 years old and over, who have been diagnosed with Type II diabetes and who have had an HbA1c measurement result recorded within the previous 6 months AND regular clients who are residents, who are 15 years old and over, who have been diagnosed with Type II diabetes and who have had an HbA1c measurement result recorded within the previous 12 months, which are disaggregated by gender by age group by locality.

From: Numerator: The number of resident clients who are aged 15 years and over who have been diagnosed with type II diabetes, and who have had one or more HbA1c tests during the last six months of the reporting period.

To: Numerator: The number of resident clients who are aged 15 years and over who have been diagnosed with type II diabetes, and who have had one or more HbA1c tests

From: Level/unit of counting:

From: Client’s ages are calculated according to the end of reporting period.

Client’s residential statuses are determined
To: Level/unit of counting:
Client’s ages are calculated according to the end of reporting period.
Client’s residential statuses are determined according to the end of reporting period.
Calculated separately for 6 months and 12 months.

From: Counting rules:
Include: Type II diabetes only.’

<table>
<thead>
<tr>
<th>Year</th>
<th>Missing data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>- 2 PHC services missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- No missing data for remaining PHC services</td>
</tr>
<tr>
<td>2011</td>
<td>- 1 PHC services missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- No missing data for remaining PHC services</td>
</tr>
<tr>
<td>2012</td>
<td>- 0 PHC services missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- No missing data for remaining PHC services</td>
</tr>
<tr>
<td>2013</td>
<td>- 0 PHC services missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- No missing data for remaining PHC services</td>
</tr>
<tr>
<td>2014</td>
<td>- 0 PHC services missing all data fields</td>
</tr>
<tr>
<td></td>
<td>- No missing data for remaining PHC services</td>
</tr>
</tbody>
</table>

Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?
Yes. See details under KPI 1.

Is there scientific evidence available to support the measure?
HbA1c is internationally accepted as the gold standard index of glycaemic control, endorsed by the WHO (89) and is the best risk marker for diabetic microvascular complications (88).

This indicator however only assesses whether a test was taken, it does not collect any information on what action was taken if a high HbA1c result was observed.
KPI 8.2 - ‘The number and proportion of Aboriginal clients with type II diabetes and whose HbA1c measurements are within certain levels’

Rationale
‘Glycosylated haemoglobin is an index of average blood glucose level for the previous 2-3 months and is used to monitor blood sugar control in people with diabetes. The level of control is a marker for increased risk of developing complications including vision loss, neuropathy, and renal disease and to a lesser extent, cardiovascular complications. The UKPDS study demonstrated significant reductions in microvascular complications with intensive control of diabetes. More recently the ADVANCE study demonstrated a significant reduction in both renal disease and cardiovascular disease in patients with improved blood pressure and diabetes control’ (10).

Definition
‘The number and proportion of resident Aboriginal clients who have type II diabetes and whose HbA1c measurement result recorded within the previous 12 months was within certain levels’ (10).

Importance of what is being measured

| What is the impact on health and on health expenditure? | Type 2 diabetes was the second leading specific cause of death for Indigenous Australians; accounting for 8% of all deaths in adults (71).

Eleven percent of Aboriginal and Torres Strait Islander people had diabetes. The age adjusted prevalence for diabetes (type 1 and 2) in Aboriginal and Torres Strait Islander Australians was three times higher Indigenous Australians in 2012-2013 compared to non-Indigenous Australians and starts at a younger age (rate ratio of 3.3) (90).

Poorly-controlled blood glucose in diabetics increases the risk of overall mortality (82) and diabetic complications such as gangrene that requires amputation (83), end stage kidney disease (84), and eye disease, particularly diabetic retinopathy (85). Indigenous Australians with type 2 diabetes have a ten-fold greater risk of kidney failure due to diabetes compared to non-Indigenous Australians (86). Early identification of poorly controlled blood sugar with the high HbA1c levels allows for improved treatment to delay or prevent complications. |
| Are policy makers and consumers concerned about the disease? | Yes, diabetes is in the ‘2014 Aboriginal and Torres Strait Islander Health Performance Framework’ (13). The Australian Government funds the following initiatives:

1. The Diabetes Care Project pilot that tests new models of |
| **Chapter 3** | **healthcare arrangements for people with Type 1 and type 2 diabetes.**  
2. The Indigenous Australians Health programme - provides diabetes prevention and management through comprehensive primary health care (diabetes and CVD) (13).  
3. General practitioner health assessments for Indigenous Australians under the Medical Benefits Scheme. These health assessments include follow-on care and incentive payments for improved management, and cheaper medicines through the Pharmaceutical Benefits Scheme (13). |
| **Can the health care system meaningfully address this disease area problem?** | **Yes, diabetes is in the ‘2014 Aboriginal and Torres Strait Islander Health Performance Framework’ (13). The Australian Government has funded the following initiatives:**  
1. The Diabetes Care Project pilot that tests new models of healthcare arrangements for people with type 1 and type 2 diabetes.  
2. The Indigenous Australians Health programme -provides diabetes prevention and management through comprehensive primary health care  
3. General practitioner health assessments for Indigenous Australians under the Medical Benefits Scheme. These health assessments include follow-on care and incentive payments for improved management, as well as cheaper medicines through the Pharmaceutical Benefits Scheme (13). |
Scientific soundness

Validity: are the data telling the truth?

<table>
<thead>
<tr>
<th>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</th>
<th>This KPI measures whether the HbA1c levels are within the normal range or whether they are elevated to reflect poor control of blood glucose level. The KPI does not provide any information on what action was taken to improve HbA1c levels if elevated. Further limitations for using HbA1c as an indicator for glycaemic control are detailed under KPI 8.1 (Number and proportion of resident clients aged ≥ 15 years and over with type 2 diabetes who have had an HbA1c measurement result recorded). Other standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do the results fall within a plausible range?</td>
<td>Using 2013 to 2014 NT AHKPI data the range reported from PHC services for HbA1c test results were:</td>
</tr>
<tr>
<td></td>
<td>• ( \leq 7% = 12% \text{ to } 77% )</td>
</tr>
<tr>
<td></td>
<td>• ( &gt;7% \leq 8% = 0% \text{ to } 38% )</td>
</tr>
<tr>
<td></td>
<td>• ( &gt;8% &lt; 10% = 0% \text{ to } 47% )</td>
</tr>
<tr>
<td></td>
<td>• ( \geq 10% = 3% \text{ to } 59% )</td>
</tr>
<tr>
<td>Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?</td>
<td>Are all Aboriginal and Torres Strait Islander residents with type 2 diabetes in the community captured by the PHC service’s database?</td>
</tr>
<tr>
<td></td>
<td>This criterion requires comparison with other datasets which is not possible as part of this evaluation.</td>
</tr>
</tbody>
</table>
| Were the data correctly extracted by the NT DoH warehouse? | Numerator: “The number of resident Aboriginal clients who have been diagnosed with type II diabetes who have had one or more HbA1c tests during the reporting period with the most recent test being:
1. less than or equal to 7% OR less than or equal to 53 mmol/mol;
2. greater than 7% but less than or equal to 8% OR greater than 53 mmol/mol but less than or equal to 64 mmol/mol;” |
| Were both numerators and denominators correct? | Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1. |
3. greater than 8% but less than 10% OR greater than 64 mmol/mol but less than 86 mmol/mol;
4. greater than or equal to 10% OR greater than or equal to 86 mmol/mol

If a client has more than one HbA1c during reporting period count the last one only.”

**Denominator:**
'The number of resident Aboriginal clients who have been diagnosed with type II diabetes and who have had one or more HbA1c tests during the reporting period' (10).

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>N/A</td>
</tr>
<tr>
<td>2011</td>
<td>N/A</td>
</tr>
<tr>
<td>2012</td>
<td>N/A</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Have the data collection methods for measuring, calculating or recording this KPI changed over time?</th>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Month</td>
<td>Version</td>
</tr>
<tr>
<td>2010</td>
<td>Oct</td>
<td>1.3.3</td>
</tr>
<tr>
<td>2013</td>
<td>March</td>
<td>2.0.2</td>
</tr>
<tr>
<td>2013</td>
<td>Sept</td>
<td>2.0.3</td>
</tr>
<tr>
<td>How complete are the data?</td>
<td>Calendar Year</td>
<td>Missing data</td>
</tr>
<tr>
<td>---------------------------</td>
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<td>--------------</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>N/A</td>
</tr>
</tbody>
</table>
|                           | 2013          | -0 PHC services missing all data fields  
-3 empty numerator cells: unclear whether these were omissions or intended to be zeros  
-No missing data for remaining PHC services |
|                           | 2014          | -0 PHC services missing all data fields  
-3 empty numerator cells: unclear whether these were omissions or intended to be zeros  
-No missing data for remaining PHC services |

| Are the data collection and analysis methods documented? | Yes. See details under KPI 1. |

| Is there scientific evidence available to support the measure? | HbA1c is internationally accepted as the gold standard index of glycaemic control, endorsed by the World Health Organization (89) and is the best risk marker for diabetic microvascular complications (88). Studies have shown reductions in diabetic complications in type 2 diabetic patients with controlled blood glucose levels (91-93). However, to control blood glucose, actions such as improving diet, taking appropriate medications, and lifestyle changes are required (94). This indicator does not measure what action, if any, was taken by the general practitioner or the patient to control blood glucose levels and therefore to reduce subsequent complications of diabetes. |
KPI 9 - ‘Number and proportion of diabetic patients with albuminuria who are on ACE inhibitor and/or ARB’ (10)

**Rationale**

‘Renal disease is a major complication of diabetes. It is first diagnosed by the detection of protein in the urine (albuminuria). Control of high blood pressure is important in slowing the progression of renal disease. Use of Angiotension Converting Enzyme inhibitor and/or Angiotension Receptor Blocker have been demonstrated to significantly improve BP control and renal deterioration’ (10).

**Definition**

‘The number and proportion of Indigenous and non-Indigenous clients who are residents, who are 15 years old and over, who have been diagnosed with Type II diabetes with albuminuria (urine ACR >3.4) who are on an ACE (Angiotension Converting Enzyme) inhibitor and/or ARB (Angiotension Receptor Blocker) during reporting period. ACE inhibitor drugs include: Ramipril, Perindopril. ARB drugs include: Ibersartan, Candisartan’ (10).

**Importance of what is being measured**

| What is the impact on health and on health expenditure? | In 2012–13, 18% of Aboriginal and Torres Strait Islander people aged ≥ 18 years had indicators of chronic kidney disease, were as likely as non-Indigenous Australians to have indicators of chronic kidney disease (rate ratio of 2.1) (95) and signs of kidney disease appear more frequently at an earlier age for Aboriginal and Torres Strait Islanders compared to non-Indigenous Australians (13). During 2008-12, 2.5% of deaths among Aboriginal and Torres Strait Islanders were due to kidney disease (13), and death due to kidney disease is 2.6 times the rate for non-Indigenous Australians, after adjusting for age differences between the two populations (13). In 2011-2013, care involving dialysis was the leading cause of hospitalisation (45%) for Aboriginal and Torres Strait Islander Australians, 10 times the rate for non-Indigenous Australians (13). |
| Are policy makers and consumers concerned about the disease? | Yes - diabetes is in the ‘2014 Aboriginal and Torres Strait Islander Health Performance Framework’ (13). The Australian Government funds a range of initiatives, some of which include the following: 1. The Diabetes Care Project pilot that tests new models of healthcare arrangements for people with Type 1 and type 2 diabetes. 2. The Indigenous Australians Health programme - provides diabetes prevention and management through comprehensive primary health care. 3. The ‘essential service standards’ (ESSENCE) project |
Chapter 3

| Chapter 3 | identifies areas of care that are needed to reduce disparity in access and outcomes for Aboriginal and Torres Strait Islanders with high blood pressure.  
3. General practitioner health assessments for Indigenous Australians under the Medical Benefits Scheme. These health assessments include measurement of blood pressure and incentive payments for improved management, as well as cheaper medicines through the Pharmaceutical Benefits Scheme (13). |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Can the health care system meaningfully address this disease area problem?</strong></td>
<td>Yes - early identification of signs of kidney disease complications in people with diabetes is one of the core functions of Aboriginal Comprehensive Primary Health Care. However, the causes of kidney disease in Aboriginal and Torres Strait Australians are multifactorial including both environmental and metabolic risk factors such as diabetes (96). Culturally appropriate, family centred approaches, engagement with communities and working collaboratively across the continuum of care and prevention are needed for primary health care to be successful in addressing these disease areas (74). Factors such as having a community based model, patient education, and education and empowerment of local health workers, have been associated with better control of hypertension and prevention of the associated complications (97).</td>
</tr>
<tr>
<td><strong>Scientific soundness</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Validity: are the data telling the truth?</strong></td>
<td>The number of people with albuminuria is being detected through this KPI however, whether they are being appropriately and effectively treated to control blood pressure or delay progression of kidney disease is not known. This indicator does not assess the content or quality of care that was provided if the clinician found that ARB or ACE wasn’t successfully controlling blood pressure and renal disease. It is also uncertain how albuminuria is measured i.e. is it measured using a point of care device or is a specimen sent</td>
</tr>
</tbody>
</table>
to the laboratory for testing? We can therefore not draw any conclusions about the sensitivity and specificity of the test used to inform this KPI.

Other standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.

| Do the results fall within a plausible range? | Using 2014 NT AHKPI data, the range of resident clients with type 2 diabetes and albuminuria who are on the following treatments:  
- ACE inhibitor: 0% to 100%*  
- ARB: 0% to 100%*  
- Both ACE and ARB 0% to 100%*  
*Reflecting the proportion of people with albuminuria who are being treated |

| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting? | Are all Aboriginal and Torres Strait Islander clients with type 2 diabetes and albuminuria in the community captured by the PHC service’s database?  
This criterion requires comparison with other datasets which is not possible as part of this evaluation. |

| Were the data correctly extracted by the NT DoH warehouse? | Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1. |

| Were both numerators and denominators correct? | Yes, but there are limitations. Standard uncertainties around numerator and denominator (people being seen outside of the PHC service, or not being entered into the system or being incorrectly entered) are detailed under KPI 1.  
**Numerator**  
1. The number of resident clients who are 15 years of age and over, and who have been diagnosed with type II diabetes with albuminuria and who are on an ACE inhibitor during the reporting period.  
2. The number of resident clients who |
Chapter 3

are 15 years old and over and who have been diagnosed with type II diabetes with albuminuria and who are on an ARB during the reporting period.

3. The number of resident clients who are 15 years of age and over and who have been diagnosed with type II diabetes with albuminuria and who are on both ACE inhibitor and ARB during the reporting period.’

**Denominator:** ‘The number of resident clients who are 15 years of age and over and who have been diagnosed with type II diabetes with albuminuria.’

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>Yes</td>
</tr>
<tr>
<td>2012</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Reliability: does the measure provide stable results across various populations and circumstances?

Have the data collection methods for measuring, calculating or recording this KPI changed over time?

<table>
<thead>
<tr>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Month</td>
</tr>
<tr>
<td>2010</td>
<td>Oct</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Change: Data sourcing to exclude paper based systems and pathology labs and pharmacies sources.

Data quality and availability

From: The data collection method will depend on a clinic’s information system. If a clinic has an electronic information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database. If a clinic’s records are paper based, the data will be input manually via the web-based data input system.

The numerator required to calculate this indicator can also be sourced by combining data from pathology labs and pharmacies using the client’s HRN number. Pathology labs can provide the HRN number of patients whose ACE test result is greater than 3.4 (i.e. patients with albuminuria) and pharmacies can provide the names of patients who are on an ACE inhibitor or ARB.

To: The data collection method will depend on a clinic’s information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database.

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>March</td>
<td>2.0.2</td>
<td>No changes.</td>
</tr>
<tr>
<td>2013</td>
<td>Sept</td>
<td>2.0.3</td>
<td>No changes.</td>
</tr>
<tr>
<td>2014</td>
<td>April</td>
<td>2.0.4</td>
<td>No changes.</td>
</tr>
<tr>
<td>2014</td>
<td>Oct</td>
<td>2.0.7</td>
<td>No changes.</td>
</tr>
</tbody>
</table>

How complete are the
<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Missing data</th>
</tr>
</thead>
</table>
| 2010          | -2 PHC services missing all data fields  
- Numerator data missing for 1 services for ACE, 10 services for ARB and 19 services for ACE and ARB  
- No data missing for the remaining PHC services |
| 2011          | -1 PHC service missing all data fields  
- Numerator data missing for 1 PHC service for ACE, 19 services for ARB, 29 for ACE and ARB. Unclear whether these were omissions or intended to be zeros  
- No data missing for remaining PHC services |
| 2012          | - Numerator data missing for 6 PHC services for ARB and 14 services for ACE and ARB. Unclear whether these were omissions or intended to be zeros  
- No data missing for remaining PHC services |
| 2013          | - Numerator data missing for 1 PHC service for ACE, 4 services for ARB, 24 for ACE and ARB. Unclear whether these were omissions or intended to be zeros  
- No data missing for remaining PHC services |
| 2014          | - Numerator data missing for 6 PHC services for ARB and 38 services for ACE and ARB. Unclear whether these were omissions or intended to be zeros  
- No data missing for remaining PHC services |

Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time? 
Yes. See details under KPI 1.

Is there scientific evidence available to support the measure? 
Good control of blood pressure in people with type 2 diabetes reduces the progression of both microvascular and macro vascular complications, including renal disease (98). ARB or ACE improves blood pressure control and renal deterioration in type 2 diabetics. However, this indicator does not assess whether the ARB or ACE have successfully controlled the blood pressure and renal deterioration in the resident clients. Although data on blood pressure control amongst type 2 diabetics is collected for KPI 13.
KPI 10 - ‘Number and proportion of Indigenous resident clients aged 15 to 54 years who have had full adult health check’ (10)

**Rationale:** ‘The evidence for screening well people for asymptomatic disease is well established for a specified number of conditions. Screening detects the disease at an earlier stage, and this allows good clinical management with the aim of reducing and preventing complications. Adult health checks indicate quality of primary health care services, with a focus on health promotion and prevention. It is also a major strategy to identify and treat sexually transmitted infections, which are mainly asymptomatic’ (10).

**Definition:** ‘The number resident clients who are 15 years to and less than 55 years of age and who have a current complete:

1. MBS item 715 Indigenous adult health check, or
2. Alternative Indigenous adult health check similar to MBS item 715.

The following mandatory items are included in the alternative Adult Health Checks for those aged 15–54 years:

**Taking the patient’s medical history**
1. Medical history, current health problems and health risk factors
2. Relevant family medical history
3. Medication usage—including OTC and medication from other doctors
4. Immunisation status (refer to the appropriate current age and sex immunisation schedule)
5. Sexual and reproductive health
6. Physical activity, nutrition and alcohol, tobacco or other substance use
7. Hearing loss
8. Mood (depression and self-harm risk)
9. Family relationships, social circumstances, and whether the patient is a carer or cared for by another person

**Examining the patient**
1. Measurement of the patient’s blood pressure, pulse rate and rhythm
2. Measurement of height and weight to calculate BMI, and if indicated, measurement of waist circumference for central obesity
3. Oral examination (gums and dentition)
4. Ear and hearing examination (otoscopy and if indicated, a whisper test)
5. Urinalysis (dipstick) for proteinuria

**Undertaking or arranging any required investigation**
Arrange or undertake any investigations as clinically indicated and consider the need for the following tests, in particular, in accordance with national or regional guidelines:
1. Fasting blood sugar and lipids
2. Pap smear
3. STI testing
4. Mammography

Assessing the patient using the information gained in the health check
Overall assessment of the patient including the patient’s level of cardiovascular risk based on consideration of evidence from patient history, examination results and results of any investigations

Initiating intervention activities as required
1. Risk factors assessment and discussion with patient or patient’s parent or carer
2. Provision of preventative advise and intervention where required
3. Interventions may include:
4. Initiation of treatment, referral and/or immunisation
5. Education, advice and/or assistance in relation to smoking, nutrition, alcohol/other substance use, physical activity (SNAP), reproductive health issues e.g. pre-pregnancy education/counselling safer sex and/or social and family issues
6. Other interventions as considered necessary.’

Importance of what is being measured

<table>
<thead>
<tr>
<th>What is the impact on health and on health expenditure?</th>
<th>These health checks cover a number of chronic, communicable and sexually transmissible infections (STIs). Chronic diseases such as cardiovascular disease, diabetes, kidney and circulatory diseases and STIs can have serious long term consequences, disproportionately affect Aboriginal and Torres Strait Islander peoples (13, 35) and represent a substantial and increasing portion of health care expenditure (99, 100, 101).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are policy makers and consumers concerned about the disease?</td>
<td>Yes – these general practitioner health assessments for Indigenous Australians under the Medical Benefits Scheme are funded by the Australian Government. These assessments include incentive payments for improved management, as well as cheaper medicines through the Pharmaceutical Benefits Scheme (102).</td>
</tr>
<tr>
<td>Can the health care system meaningfully address this disease area problem?</td>
<td>This is a screening test, so it depends on whether the disease detected can be treated but yes – full adult health checks are one of the core functions of Aboriginal and Torres Strait Islander Primary Health care.</td>
</tr>
</tbody>
</table>
### Scientific soundness

#### Validity: are the data telling the truth?

<table>
<thead>
<tr>
<th><strong>Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)</strong></th>
<th>Standard uncertainties around the KPI able to measure/detect the disease condition are detailed under KPI 1.</th>
</tr>
</thead>
</table>
| **Do the results fall within a plausible range?** | Using 2010 to 2014 NT AHKPI data the range reported for the proportion of Aboriginal and Torres Strait Islander resident clients aged 15 to 55 years who had a full adult health check from PHC services were:  
  - Full adult health check: 0% to 92%  
  - Similar alternative adult health check: 0% to 67% |
| **Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?** | Are all Aboriginal and Torres Strait Islander resident clients aged 15 to 54 years in the community captured by the PHC service’s database?  
  - This criterion requires comparison with other datasets which is not possible as part of this evaluation.  
  - Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1. |
| **Were the data correctly extracted by the NT DoH warehouse?** | Yes. |
| **Were both numerators and denominators correct?** | Yes.  
<table>
<thead>
<tr>
<th><strong>Year</strong></th>
<th><strong>Do numerators add up to denominator?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>Yes</td>
</tr>
<tr>
<td>2012</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Numerator:**  
*MBS Item 715 Indigenous Adult Health Check*  
The number of resident Indigenous clients who are aged 15 years to less than 55 years of age and who have a current and complete MBS Item 715 Indigenous adult health check at the end of the current reporting period.
**Alternative Indigenous Adult Health Check**

The number of resident Indigenous clients who are aged 15 years to less than 55 years of age and who have a current and complete Alternative Indigenous Health Check at the end of the current reporting period.

**Denominator:**

‘Number of resident Indigenous clients who are aged 15 years to less than 55 years of age as at the end of the reporting period.’

Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Oct</td>
<td>1.3.3</td>
<td></td>
<td>‘Change: Collapsing of Medicare Item No 710 into 715. ’</td>
</tr>
</tbody>
</table>

**Definition**

*From:* ...who have a current complete MBS item 710 Indigenous adult health or alternative Indigenous adult health check similar to MBS item 710 during reporting period.

*To:* ...who have a current complete:

a. MBS item 715 Indigenous adult health or

b. alternative Indigenous adult health check similar to MBS item 715.

The following mandatory items are included in the alternative Adult Health Checks for those aged 15–54 years:

[Inserted 24 Alternative Care Plan ‘mandatory items’ from the ‘SCARF Technical specifications for Essential Indicators Version 4.0 July 2010’].

**Calculation Numerator**

*From:* ...who have a current and complete MBS item 710 adult health check at the end of the current...
reporting period and were aged:

a. 15-24 years (Item 710)
b. 25-44 years (Item 710)
c. 45-54 years (Item 710)

to have a current and complete MBS item 715 adult health check at the end of the current reporting period and were aged:

d. 15-24 years (Item 715)
e. 25-44 years (Item 715)
f. 45-54 years (Item 715)

change: Specified period to include calendar year

Calculation - Specified period

From: Financial year
To: Financial year or Calendar year

change: Data sourcing to exclude paper based systems sources.

Data quality and availability

From: The data collection method will depend on a clinic’s information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database. If a clinic’s records are paper based, the data will be input manually via the web-based data input system.
To: The data collection method will depend on a clinic’s information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database.

change: Statement of alignment to Healthy For Life.

Sound methodology

Added: Definition is aligned to the 'SCARF Technical specifications for Essential Indicators Version 4.0 July 2010' that is being developed as a national standard.
<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Change: Counting Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>March</td>
<td>2.0.2</td>
<td>Description: Update the counting rules to correctly reflect current CARPA recommendations. To: CARPA recommends all adults over 15 years have a health check every 2 years. Therefore, all adults who have had a health check in the 2 years prior to the end of the reporting period should be included in the count, not just those who received a health check within the reporting period. Each client to be counted once only. Population is as at ‘end of reporting period.’</td>
</tr>
</tbody>
</table>

| Change: Specified period |
| Description: Added an additional time period to the KPI |
| From: Financial year or Calendar year. To: Two-year period commencing on either 1st July or 1st January. |

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Changes Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Sept</td>
<td>2.0.3</td>
<td>No changes made.</td>
</tr>
<tr>
<td>2014</td>
<td>April</td>
<td>2.0.4</td>
<td>No changes made.</td>
</tr>
<tr>
<td>2014</td>
<td>Oct</td>
<td>2.0.7</td>
<td>No changes made.</td>
</tr>
</tbody>
</table>

### How complete are the data?

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Missing data Full adult health check</th>
<th>Missing data Alternative similar health check</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>-1 PHC service missing all data fields -4 empty numerator cells: unclear whether these were omissions or intended to be zeros</td>
<td>-1 PHC service missing all data fields -65 empty numerator cells: unclear whether these were omissions or intended to be zeros -1 PHC service used zero reporting</td>
</tr>
<tr>
<td>2011</td>
<td>-1 PHC service missing all data fields -4 empty numerator cells: unclear whether these were omissions or intended to be zeros -Zero reporting not used. We therefore cannot interpret the significance of a missing value for these services</td>
<td>-1 PHC service missing all data fields -58 empty numerator cells: unclear whether these were omissions or intended to be zeros -Zero reporting not used. We therefore cannot interpret the significance of a missing value for these services</td>
</tr>
<tr>
<td>2012</td>
<td>-0 PHC services missing all data fields -2 empty numerator cells: unclear whether these were</td>
<td>-0 PHC services missing all data fields -56 empty numerator cells: unclear whether these were</td>
</tr>
<tr>
<td>Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?</td>
<td>Yes. See details under KPI 1.</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Is there scientific evidence available to support the measure?</td>
<td>Health checks allow for early detection and early treatment of disease, they improve the frequency of preventive care and support for patient behaviour change (103), however, this KPI only measures whether a health check was conducted, it does not assess what action was taken after or the impact on health outcomes.</td>
<td></td>
</tr>
</tbody>
</table>
KPI 11 - ‘Number and proportion of Indigenous resident clients aged 55 years and over who have had full adult health check’

**Rationale:** ‘The evidence for screening people for asymptomatic disease is well established for a specified number of conditions. Screening detects the disease at an earlier stage, and this allows good clinical management with the aim of reducing and preventing complications’ (10).

**Definition:**
‘The number of resident clients who are 55 years old and over and who have a current complete:

MBS item 715 Indigenous adult health or Alternative Indigenous adult health check similar to MBS item 715.

The following mandatory items are included in the alternative Adult Health Checks for those aged 55 years and over:

**Taking the patient’s medical history**
1. Medical history, current health problems and health risk factors
2. Relevant family medical history

**Examining the patient**
Medical
1. Medication review
2. Measurement of the patient’s blood pressure, pulse rate and rhythm
3. Continence
4. Immunisation status (refer to the appropriate current age and sex immunisation schedule)
5. Measurement of height and weight to calculate BMI, and if indicated, measurement of waist circumference for central obesity
6. Urinalysis (dipstick) for proteinuria
7. Trichiasis check where indicated
8. Skin examination
9. Reproductive and sexual health examination
10. Physical function
11. Activities of daily life
12. Falls in the last 3 months
13. Psychological function
14. Cognition
15. Mood
Social function
16. Availability and adequacy of paid and unpaid help when needed or wanted
17. Caring for another person
18. Consultation with the patients carer (where applicable).’
Importance of what is being measured

| What is the impact on health and on health expenditure? | These health checks cover a number of chronic, communicable and sexually transmissible infections (STIs). Chronic diseases such as cardiovascular disease, diabetes, kidney and circulatory diseases and STIs can have serious long term consequences, disproportionately affect Aboriginal and Torres Strait Islander peoples (13, 35) and represent a substantial and increasing proportion of health care expenditure (99, 100, 101). |
| Are policy makers and consumers concerned about the disease? | Yes – these general practitioner health assessments for Indigenous Australians under the Medical Benefits Scheme are funded by the Australian Government. These assessments include incentive payments for improved management, as well as cheaper medicines through the Pharmaceutical Benefits Scheme (102). |
| Can the health care system meaningfully address this disease area problem? | This is a screening test, so it depends on whether the disease detected can be treated but yes – full adult health checks are one of the core functions of Aboriginal and Torres Strait Islander Primary Health care. |

Scientific soundness

Validity: are the data telling the truth?

| Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?) | Standard uncertainties around the KPI able to measure/detect the disease condition are detailed under KPI 1. |
| Do the results fall within a plausible range? | Using 2010 to 2014 NT AHKPI data the range reported for the proportion of Aboriginal and Torres Strait Islander resident clients aged ≥ 55 years who had a full adult health check from PHC services were:  
  • Full adult health check: 0% to 100%  
  • Similar alternative adult health check: 0% to 83% |
| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting? | Are all Aboriginal and Torres Strait Islander resident clients aged 15 to 54 years in the community captured by the PHC service’s database? This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
Were the data correctly extracted by the NT DoH warehouse?

Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and its limitations in KPI 1.

Were both numerators and denominators correct?

Yes - all numerators and denominators fell into plausible ranges:

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>Yes</td>
</tr>
<tr>
<td>2012</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Numerator:

*MBS Item 715 Indigenous Adult Health Check (55+)*

*The number of resident Indigenous clients who are aged 55 years and over and who have a current and complete MBS Item 715 adult health check as at the end of the reporting period.*

*Alternative Indigenous Adult Health Check (55+)*

*The number of resident Indigenous clients who are aged 55 years and over and who have a current and complete Alternative Indigenous Health Check as at the end of the reporting period.*

Denominator:

*‘Number of resident Indigenous clients who are aged 55 years and over as at the end of the reporting period.’*
Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Month</td>
</tr>
<tr>
<td>2010</td>
<td>Oct</td>
</tr>
</tbody>
</table>

`Change: Collapsing of Medicare Item No 704/706 into 715 and further alignment to Healthy For Life definitions for alternative care plans.

Definition
From:...who have a current complete MBS item 704 or 706 Indigenous adult health or alternative Indigenous adult health check similar to MBS item 704 or 706 during reporting period.

To:...who have a current complete:
- MBS item 715 Indigenous adult health or
- alternative Indigenous adult health check similar to MBS item 715 during reporting period.

The following mandatory items are included in the alternative Adult Health Checks those aged 55 years and over: [Inserted 18 Alternative Care Plan ‘mandatory items’ from the ‘SCARF Technical specifications for Essential Indicators Version 4.0 July 2010’].

Calculation Numerator
From:...who have a current and complete MBS Item 704 or 706 adult health check at the end of the current reporting period and were aged:
- 55-64 years (Item 704)
- 65 years and above (Item 704)
- 55-64 years (item 706)
- 65 years and above (Item 706)

To:...who have a current and complete MBS Item 715 adult health check at the end of the current reporting period and were aged:
### Chapter 3

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
|   | a. 55-64 years (Item 715)  
b. 65 years and above (Item 715) |   |

**Counting rules—includes, exclusions:**  
*From:* Adult health checks must include the criteria of the MBS items 710, 704 or 706 (as appropriate).

The health check must be complete to be included in the data collection process (initiation is not sufficient).

Adult health checks (item 710) are valid for two years, therefore all adults with a current/valid health check at the end of the reporting period should be included in the data collection process, not just those adults who received a health check during the reporting period.

Adult health checks (item 704 and 706) are valid for one year, therefore all adults with a current/valid health check at the end of the reporting period should equate to all adults who received a health check in the reporting period.

*To:* Adult health checks must include the criteria of the MBS item 715.

The health check must be complete to be included in the data collection process (initiation is not sufficient).

Adult health checks (item 715) are valid for one year, therefore all adults with a current/valid health check at the end of the reporting period should be included in the data collection process, not just those adults who received a health check during the reporting period.

**Change:** Specified period to include calendar year  
**Calculation - Specified period**  
*From:* Financial year  
*To:* Financial year or Calendar year
Change: Data sourcing to exclude paper based systems and Medicare Australia sources.

Data quality and availability

From: The data collection method will depend on a clinic’s information system. If a clinic has an electronic information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database. If a clinic’s records are paper based, the data will be input manually via the web-based data input system. The numerator data required to calculate this indicator can also be obtained from Medicare Australia by requesting a report on the number of 704 and 706 item claims by provider location.

To: The data collection method will depend on a clinic’s information system. If a clinic has an electronic information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database.

Change: Statement of alignment to Healthy For Life.

Sound methodology

Added:
Definition is aligned to the ‘SCARF Technical specifications for Essential Indicators Version 4.0 July 2010’ that is being developed as a national standard.’

2013 March 2.0.2

*Change: Definition
Description: Minor edit to correct sentence.

From: The following mandatory items are included in the alternative Adult Health Checks those aged 55 years and over:
To: The following mandatory items are included in the alternative Adult Health Checks for those aged 55 years and over:

**Change: Counting Rules**
**Description:** Add definition to counting rules to correctly reflect the data requirements for this KPI

To: CARPA recommends all adults over 15 years have a health check every 2 years. Therefore, all adults who have had a health check in the 2 years prior to the end of the reporting period should be included in the count, not just those who received a health check within the reporting period. Each client to be counted once only. Population is as at ‘end of reporting period.’

**Change: Specified period**
**Description:** Added an additional time period to the KPI

From: Financial year or Calendar year.
To: Two year period commencing on either 1st July or 1st January.

<table>
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How complete are the data?

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**Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?**

Yes. See details under KPI 1.

**Is there scientific evidence available to support the measure?**

Health checks allow for early detection and early treatment of disease, they improve the frequency of preventive care and support for patient behaviour change (103), however, this KPI only measures whether a health check was conducted, it does not assess what action was taken after or the impact on health outcomes.
**KPI 12 - ‘Number and proportion of resident women who have had at least one Pap test during reporting period’**

**Rationale** ‘Increasing participation in cervical screening is important to reduce the number of women who present with cervical cancer and ultimately die from the disease. A range of strategies actively targets women in the 20-69 years inclusive age group. It is recommended that women in the target age group, who have ever been sexually active, have a pap smear every two years.’

**Definition** ‘The number and proportion of women aged 20-69 years inclusive who are residents and who have had at least one pap smear test during the specified reporting period’ (10).

**Importance of what is being measured**

<table>
<thead>
<tr>
<th>What is the impact on health and on health expenditure?</th>
<th>Between 2012 and 2013, the incidence of cervical cancer in Indigenous women was more than twice that of non-Indigenous women and the age-adjusted mortality rate was 4 times the non-Indigenous rate (104). Indigenous women are reported to have poorer outcomes (105).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are policy makers and consumers concerned about the disease?</td>
<td>Yes, in early 1991, The Australian Government implemented The National Cervical Screening Program. This program encourages women aged 20-69 years to have two yearly Papanicolaou (Pap) smear tests to screen for cervical abnormalities. It also provides training for Pap smear testing and runs quality assurance programs for diagnostic laboratories. The aim of this program is to diagnose and treat cervical abnormalities early with the aim of reducing the incidence of cervical cancer and mortality from cervical cancer (106).</td>
</tr>
<tr>
<td>Can the health care system meaningfully address this disease area problem?</td>
<td>Yes, screening services are available and part of the core functions of primary health care in the NT. Since the introduction of The National Cervical Screening Program, it is estimated that 70% of squamous cell carcinomas of the cervix have been prevented by early diagnosis and management of cervical abnormalities (107-109). However, there is evidence that there is under screening amongst Indigenous women (104). A range of barriers to cervical screening for Indigenous women have been identified which include: a lack of culturally appropriate services, linguistic barriers, fear and misunderstanding of the procedure and of cervical cancer itself, feelings of shame and embarrassment, fear about lack of confidentiality of results and geographical (physical accessibility) barriers (110-112). Community participation in planning and delivery, having an Indigenous health worker who focuses on public health education and promotion, and having a female GP, increase the uptake of cervical screening (111). Using approaches such as these will be needed to address the aforementioned barriers to ensure the health care system can meaningfully address this disease area.</td>
</tr>
</tbody>
</table>
Scientific soundness

Validity: are the data telling the truth?

| Does the information collected measure what it is supposed to measure? (I.e. has the indicator been tested and validated to measure what it is intended to measure?) | Limitations with this indicator include: The Pap test is used as a screening tool as part of The National Cervical Screening Program. While this is a useful indicator, it is not diagnostic of cervical cancer; it just identifies those who may have abnormalities in the cells of the cervix, particularly pre-cancerous lesions. If abnormal cells are found, further testing is required to confirm a diagnosis (104). Furthermore, Pap smear tests collect a sample of cells from the surface of the cervix at a certain point in time. This sample is then examined in a laboratory. There are high quality standards in place as part of the National Cervical Screening Program to monitor the quality of laboratories in Australia that report on cervical cytology results (106). However, this testing system does not accurately detect all abnormalities that may be present in the cervix. The specificity of the test to detect precancerous abnormalities ranges from 62% to 98% and the sensitivity of a single Pap smear test ranges from 40% to 86% (113). The strength and accuracy of this indicator relies on repeated screening visits at regular intervals to allow for detection of precancerous abnormalities during the precancerous stage (113). There are some cervical cancers (e.g. small and large cell neuroendocrine cancers of the cervix) that do not have a precancerous stage, and therefore won’t be detected by cervical screening (114). This KPI only assesses who has been screened for cervical abnormalities – it does not assess what happened once an abnormality is detected. Other standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1. |
| Do the results fall within a plausible range? | Using 2010 to 2014 NT AHKPI data the range reported from PHC services were:  
- 0% to 97% |
| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) | Are all women aged 20-69 years in the community captured by the PHC service’s database? | This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and its limitations in KPI 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>Yes</td>
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<tr>
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<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Numerator:
‘1. The number of resident women aged 20-69 years inclusive and who have had at least one pap smear test during the previous 2 reporting periods.
2. The number of resident women aged 20-69 years inclusive and who have had at least one pap smear test during the previous 3 reporting periods.
3. The number of resident women aged 20-69 years inclusive and who have had at least one pap smear test during the previous 5 reporting periods.’

Denominator:
‘The number of resident women aged 20-69 years of age.’

Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
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<td></td>
<td></td>
<td>Rationale</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>From: ...women in the 18-70 years age group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>To: ...women in the 20-69 years inclusive age group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Definition</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>From: ...women in the 18-70 years age group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>To: ...women in the 20-69 years inclusive age</td>
</tr>
</tbody>
</table>
Chapter 3

Calculation – Numerator
From: The number of women aged 18-70 years who are residents and who have had at least one PAP smear test during reporting period.
To: The number of women aged 20-69 years inclusive who are residents and who have had at least one PAP smear test during reporting period and were aged:
   a. 20-34 years
   b. 35-49 years
   c. 50-69 years

Calculation – Denominator
From: The number of women aged 18-70 years who are residents at the end of reporting period
To: The number of women aged 20-69 years inclusive who are residents at the end of reporting period and were aged:
   a. 20-34 years
   b. 35-49 years
   c. 50-69 years

Change: Specified period to include calendar year

Calculation - Specified period
From: Collect data every financial year for the previous 2 financial years
To: Collect data every financial year or calendar year for the previous 2 financial or calendar years

Change: Data sourcing to exclude paper based systems and pathology lab sources.

Data quality and availability
From: The data collection method will depend on a clinic’s information system. If a clinic has an electronic information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database. If a clinic’s records are paper based, the data will be input manually via the web-based data input system.
The numerator data required to calculate this indicator can also be sourced from pathology labs e.g. Western Diagnostic Pathology, who can provide the number of PAP smear tests done by them by provider number in the
To: The data collection method will depend on a clinic’s information system e.g. Communicare, Ferret, or PCIS, the data required to calculate this performance indicator will be extracted directly from their database’ (10).

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Version</th>
<th>Description</th>
</tr>
</thead>
</table>
| 2013   | March   | 2.0.2   | ‘Change: Counting Rules
From: -
To: Each client to be counted only once…’ |
|        |         |         | Change: Specified period                                                    |
|        |         |         | Description: adding an additional time period to the KPI                  |
|        |         |         | From: Collect data every financial year or calendar year for the previous 2 financial or calendar years. |
|        |         |         | To:                                                                          |
|        |         |         | 1. Collect data every financial year or calendar year for the previous 2 financial or calendar years. |
|        |         |         | 2. Collect data every financial year or calendar year for the previous 3 financial or calendar years. |
|        |         |         | 3. Collect data every financial year or calendar year for the previous 5 financial or calendar years.’ |
| 2013   | Sept    | 2.0.3   | No changes made.                                                           |
| 2014   | April   | 2.0.4   | No changes made.                                                           |
| 2014   | Oct     | 2.0.7   | No changes made.                                                           |

### How complete are the data?

<table>
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<td>- 1 empty numerator cell: unclear whether this was an omission or intended to be a zero</td>
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<td>- No missing data for remaining PHC services</td>
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<tr>
<td>2011</td>
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<tr>
<td></td>
<td>- No missing data for remaining PHC services</td>
</tr>
</tbody>
</table>
### Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?

<table>
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<td>No missing data for PHC services</td>
</tr>
<tr>
<td>2014</td>
<td>No missing data for PHC services</td>
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</tbody>
</table>

Yes. See details in KPI 1.

### Is there scientific evidence available to support the measure?

Cervical cancer has a precancerous stage that can last for many years before the disease becomes invasive. This provides an opportunity for detection and treatment (115). Studies show that regular screening for cervical cancer for women aged 20-69 (and subsequent management of abnormalities) reduces risk of mortality from cervical cancer (104, 116-118).

This KPI only assesses how many women have been screened, it does not provide any information on what happened once an abnormality was found and on the quality of care that was given.
**KPI 13** – ‘Number and proportion of Indigenous clients who have diabetes type 2 and who have good BP control within 12 month period’

**Rationale**
‘Good control of BP in people with diabetes reduces the incidence of cardiovascular disease and delays the progression of renal disease’ (10).

**Definition:**
‘Number and proportion of Aboriginal clients aged 15 and over who have type 2 diabetes and who have good BP control’ (10).

**Importance of what is being measured**

| What is the impact on health and on health expenditure? | In 2011-2012, type 2 diabetes was the second leading specific cause of death for Aboriginal and Torres Strait Islander Australians, accounting for 8% of all adult deaths (71).
In 2012–13, 20% of Aboriginal and Torres Strait islander people aged ≥ 18 years had high blood pressure (140/90 mm/Hg). Aboriginal and Torres Strait Islander people aged ≥ 18 years were more likely than non-Indigenous people to have high blood pressure (rate ratio of 1.2) (119). |
| Are policy makers and consumers concerned about the disease? | Yes – diabetes is in the ‘2014 Aboriginal and Torres Strait Islander Health Performance Framework’ (13).
The Australian Government funds a range of initiatives, some of which include the following:
1. The Diabetes Care Project pilot that tests new models of healthcare arrangements for people with Type 1 and type 2 diabetes.
2. The Indigenous Australians Health programme - provides diabetes prevention and management through comprehensive primary health care.
3. The ‘essential service standards’ (ESSENCE) project identifies areas of care that are needed to reduce disparity in accesses and outcomes for Aboriginal and Torres Strait Islanders with high blood pressure.
3. General practitioner health assessments for Indigenous Australians under the Medical Benefits Scheme. These health assessments include measurement of blood pressure and incentive payments for improved management, as well as cheaper medicines through the Pharmaceutical Benefits Scheme (13). |
| Can the health care system meaningfully address this disease area problem? | Yes – measurement and effective management of blood pressure is one of the core functions of Aboriginal Comprehensive Primary Health Care. |
High blood pressure is associated with a range of life style factors and socioeconomic determinants (120, 121), some of which go beyond the control of the health care system.

Factors such as having a community based model, patient education, and education and empowerment of local health workers, have been associated with better control of hypertension and prevention of the associated complications (97).

### Scientific soundness

#### Validity: are the data telling the truth?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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</thead>
</table>
| **Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?)** | Standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1.  
- An accurate diagnosis of high blood pressure can be affected by the general practitioner taking the test and reading the results, the instrument used and on the patient (122, 123).  
- This indicator does not provide any information on what proportion of patients had their blood pressure under control within the last 12 months. |
| **Do the results fall within a plausible range?**                                              | Using 2014 NT AHKPI data the range reported from PHC services for:     |
|                                                                                              | - The proportion of type 2 diabetic clients with a blood pressure reading ≤ 130/180 = 24% to 80%  
- The proportion of clients with type 2 diabetes who had a blood pressure test = 29% to 100% |
| **Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting?** | Are all Aboriginal and Torres Strait Islander clients aged ≥ 15 years who have type 2 diabetes in the community captured by the PHC service’s database?  
This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
| **Were the data correctly extracted by the NT DoH warehouse?**                                | Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1. |
Were both numerators and denominators correct?

Yes - all numerators and denominators fell into plausible ranges:

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<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
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<td>2013</td>
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</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Numerator:
‘a. The number of resident clients who are indigenous, have Type II diabetes and whose blood pressure measurement result, recorded within the previous 6 months, was less than or equal to 130/80 mmHg.
b. The number of resident clients who are indigenous, have Type II diabetes and who have had a blood pressure measurement result, recorded within the previous 6 months.’

Denominator:
‘a. The number of resident clients who are indigenous, have Type II diabetes and who have had a blood pressure measurement result, recorded within the previous 6 months.
b. The number of resident clients, who are indigenous, have Type II diabetes.’
Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Have the data collection methods for measuring, calculating or recording this KPI changed over time?</th>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
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<tr>
<td>2013</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td>No missing numerator or denominator data for any of the PHC services</td>
</tr>
</tbody>
</table>

Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time? Yes. See details under KPI 1.

| Is there scientific evidence available to support the measure? | Good control of blood pressure in people with type 2 diabetes reduces the progression of microvascular and macro vascular complications (98). However, as with the control of blood glucose levels, controlling blood pressure requires action such as life style changes and or taking appropriate medications (94). This indicator does not measure what action, if any, was taken by the general practitioner or the patient to control blood pressure levels and therefore to reduce subsequent complications of diabetes. |
**KPI 14** - ‘Number and proportion of Indigenous ARF / RHD clients who are prescribed to be requiring 2-4 weekly BPG Penicillin Prophylaxis and have received injections over a 12 month period’

**Rationale** ‘4 weekly BPG Penicillin secondary prophylaxis is currently the most cost effective intervention in preventing a recurrence of Acute Rheumatic Fever (ARF) and hence the deterioration of the heart valves (mitral and aortic) and subsequently the development of Rheumatic Heart Disease (RHD)’ (10).

**Definition** ‘The proportion of Indigenous patients with a diagnosis of ARF or RHD who are prescribed as requiring 4 weekly BPG penicillin injections over a 12 month period and receive injections (adherence)’ (10).

**Importance of what is being measured**

| What is the impact on health and on health expenditure? | The prevalence of ARF and RHD in Aboriginal and Torres Strait Islander Australians living in the NT was 20.3 per 1,000, 4.5 per 1,000 in northern and central regions of Queensland (QLD), and 3.3 per 1,000 in Western Australia (WA) (13). These prevalence rates are amongst the highest in the world (124-127).

Aboriginal and Torres Strait Islanders have a seven-fold greater risk of being hospitalised from Acute Rheumatic Fever (ARF) and Rheumatic Heart Disease (RHD) (128), and nearly 20 fold greater risk to die from these diseases compared to non-Indigenous Australians (129). |
| Are policy makers and consumers concerned about the disease? | Yes, there are range of Government funded initiatives implemented aimed at reducing the prevalence and impact of ARF/RHD:

1. The Better Cardiac Care for Aboriginal and Torres Strait Islander People initiative aimed at strengthening the diagnosis, notification and follow up of RHD,

2. The Essential Service Standards for Equitable National Cardiovascular Care (ESSENCE) for Aboriginal and Torres Strait Islander People project. This project identifies areas of care that are needed to reduce the disparity in access and outcomes for circulatory diseases including cardiovascular conditions associated with RHD. This program is also developing and piloting a primary health cardiovascular care resource kit.

3. RHD registers and control programmes in NT, WA, QLD and SA to improve case detection, diagnosis and access to antibiotic injections (secondary prophylaxis)

4. The National Coordination Unity that develops...
national education, training and self-management resource and is developing a performance monitoring system, to improve collection of data and reporting on incidence and prevalence of ARF and RHD (13).

| Can the health care system meaningfully address this disease area problem? | Register based control programmes that include improved patient care, patient education and regular delivery of secondary prophylaxis have been shown to be effective in controlling this disease (127), and there has been some success with current control programs in place in the NT, SA, QLD and in New South Wales (130). However, interventions that also address the socioeconomic determinants (overcrowded housing, poor nutrition, poor hygiene and sanitation, and poor access to appropriate healthcare services (131)) that underpin this disease are key to the successful prevention and management of these diseases (127). ARF has been successfully controlled in many developed communities and countries around the world through addressing these socioeconomic factors (131). |

Scientific soundness

Validity: are the data telling the truth?

| Does the information collected measure what it is supposed to measure? (i.e. has the indicator been tested and validated to measure what it is intended to measure?) | Standard uncertainties around the KPI being able to measure/detect the disease condition are detailed under KPI 1. |
| Do the results fall within a plausible range? | Using 2013 to 2014 NT AHKPI data the range of resident clients prescribed to be requiring prophylaxis and who have received injections over a 12-month period from PHC services was: 
  • 0% to 100% |
| Is there reasonable assurance that the data recording (into electronic medical record) and subsequent collection (of aggregate data using appropriate software) methods being used do not produce consistently over-counting or under-counting? | Are all clients who are prescribed to be requiring 2-4 weekly BPG Penicillin Prophylaxis in the community captured by the PHC service’s database? This criterion requires comparison with other datasets which is not possible as part of this evaluation. |
Were the data correctly extracted by the NT DoH warehouse?

Systematic checks of the data are performed once the data reach the NT DoH warehouse. Please see detail of this and it limitations in KPI 1.

Were both numerators and denominators correct?

Yes - all numerators and denominators fell into plausible ranges.

<table>
<thead>
<tr>
<th>Year</th>
<th>Do numerators add up to denominator?</th>
</tr>
</thead>
<tbody>
<tr>
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<td>N/A</td>
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<tr>
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<tr>
<td>2013</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The numerator is categorised into 3 groups:
The number of resident Indigenous clients who have been diagnosed with ARF/RHD who are prescribed to be requiring 2-4 weekly BPG Penicillin Prophylaxis and:

a. have received 80% of their injections due at the end of the reporting period.

b. have received equal to or greater than 50% to less than 80% of their injections due at the end of the reporting period.

c. have received less than 50% of their injections due at the end of the reporting period.

Denominator:
‘The number of resident Indigenous clients who have been diagnosed with ARF/RHD and who are prescribed to be requiring 2-4 weekly BPG Penicillin Prophylaxis during the reporting period.’
Reliability: does the measure provide stable results across various populations and circumstances?

<table>
<thead>
<tr>
<th>Definition version</th>
<th>Changes made as written in the NT AHKPI Definitions Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Month</td>
</tr>
<tr>
<td>2010</td>
<td>Oct</td>
</tr>
<tr>
<td>2013</td>
<td>March</td>
</tr>
<tr>
<td>2013</td>
<td>Sept</td>
</tr>
<tr>
<td>2014</td>
<td>April</td>
</tr>
</tbody>
</table>
| 2014   | Oct   | 2.0.7   | ‘Change: numerator  
From: The number of resident Indigenous clients who have been diagnosed with ARF/RHD who are prescribed to be requiring 2-4 weekly BPG Penicillin Prophylaxis and have received 80% of their injections due at the end of the reporting period.’  
To: ‘a. The number of resident Indigenous clients who have been diagnosed with ARF/RHD who are prescribed to be requiring 2-4 weekly BPG Penicillin Prophylaxis and have received equal to or greater than 50% to less than 80% of their injections due at the end of the reporting period.  
b. The number of resident Indigenous clients who have been diagnosed with ARF/RHD who are prescribed to be requiring 2-4 weekly BPG Penicillin Prophylaxis and have received less than 50% of their injections due at the end of the reporting period.’” |
## How complete are the data?

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Missing data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>N/A</td>
</tr>
<tr>
<td>2011</td>
<td>N/A</td>
</tr>
<tr>
<td>2012</td>
<td>N/A</td>
</tr>
</tbody>
</table>
| 2013          | - 13 PHC services missing all data fields  
- 23 empty numerator cells: unclear whether these were omissions or intended to be zeros  
- Zero reporting not used. We therefore cannot interpret the significance of these missing values  
- No missing data for remaining PHC services |
| 2014          | - 8 PHC services missing all data fields  
- 16 empty numerator cells: unclear whether these were omissions or intended to be zeros  
- Zero reporting not used. We therefore cannot interpret the significance of these missing values  
- No missing data for remaining PHC services |

## Are the data collection and analysis methods documented in writing and being used to ensure the same procedures are followed each time?

Yes. See details under KPI 1.

## Is there scientific evidence available to support the measure?

Reducing the prevalence and impact of RHD requires early diagnosis of ARF and effective delivery of secondary prophylaxis (132). Secondary prophylaxis is a cost-effective way of controlling RHD at the population level (133); however, adherence to regular prophylaxis regimens is critical for this to be effective.
Pilot-testing the survey questionnaires

We received feedback (shown in Appendix 9) from six individuals from staff at one PHC service in NT, and from staff at NT DoH and AMSANT, but no feedback for the survey to the higher level planners in time for incorporating their suggestions. Overall, feedback was it was a good, well designed survey that was not ‘too onerous’. Suggestions for improving the questionnaire included allowing more space for comments and having more questions with tick box responses to reduce the time for completing the questionnaire. However, we did not adopt the latter suggestion because we preferred to receive open-ended responses.

Results from the questionnaire to primary health care staff

Of the questionnaires sent to 84 PHC (52 NT DoH and 32 ACCHOs) we received only 13 responses, covering 23 services, from the following individuals (Table 4).

Table 4: Job roles and affiliations of respondents to questionnaire to PHC staff

<table>
<thead>
<tr>
<th>Job</th>
<th>Number of respondents</th>
<th>Number of PHC services covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>CQI facilitator</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>District manager</td>
<td>2</td>
<td>One unspecified and the other covers Top End Central district</td>
</tr>
<tr>
<td>Assistant manager of a PHC outreach team</td>
<td>1</td>
<td>1 (did not state service)</td>
</tr>
<tr>
<td>Primary health care manager</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Data Integrity/Medicare Claims Coordinator</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Information and reporting coordinator</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Clinic coordinator</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>23</td>
</tr>
</tbody>
</table>
In the following section, I first state the question as posed in the questionnaire and follow this with my assessment of the responses.

_How do you or your service use the NT AHKPIs?_  
All respondents use the indicators for planning their primary health care services.

_Do you use the NT AHKPIs for service planning, CQI, Feedback to communities, other (please specify)?_  
Sixty-two percent (8/13) of respondents use the indicators for service planning, CQI and feedback to communities. One of these respondents added: ‘*I also use it to promote efficient service and innovative programs within the communities*’. Fifteen percent (2/13) use them for service planning and CQI only, 15% (2/13) use them for service planning only, and one uses them for CQI and feedback to communities.

_How useful were the NT AHKPIs in assisting with service planning, CQI, Feedback to communities and other (please specify)?_  
Overall, most respondents (69%) found the indicators to be ‘very useful’ for service planning, and CQI, and half of the respondents found them ‘very useful’ for feedback to communities (Table 5). The two respondents who selected the other option found them ‘very useful’ for ‘Staff motivation. Realigning resources across a district’ and for ‘Feedback to Managers on progress and work completed’.

_'Table 5: Participant responses to question 6: ‘How useful were the NT AHKPIs in assisting with service planning, CQI, feedback to communities and other’_'

<table>
<thead>
<tr>
<th></th>
<th>Service planning n (%)</th>
<th>CQI n (%)</th>
<th>Feedback to communities n (%)</th>
<th>Other n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very useful</td>
<td>9 (69)</td>
<td>9 (69)</td>
<td>6 (50)</td>
<td>3 (100)</td>
</tr>
<tr>
<td>Somewhat useful</td>
<td>4 (31)</td>
<td>4 (31)</td>
<td>3 (25)</td>
<td></td>
</tr>
<tr>
<td>Not very useful</td>
<td></td>
<td></td>
<td>1 (8.3)</td>
<td></td>
</tr>
<tr>
<td>Not useful at all</td>
<td></td>
<td></td>
<td>2 (16)</td>
<td></td>
</tr>
<tr>
<td>Total responses</td>
<td>13</td>
<td>13</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

_What value do you see to the NT AHKPIs?_  
All except one respondent reported the indicators to be valuable; this person lived in a community where only 30% of the population are Aboriginal and/or Torres Strait Islander.
How do you explore variations you see in the NT AHKPIs over time (e.g. explore other data sources such as work force data or speak to the community or staff)?

Sixty-two per cent (8/13) of respondents answered this question, and overall they explore variations by speaking with their staff and with the community, and cross referencing with other reports such as the ‘Traffic Light Report’, and audits of PCIS.

**NT AHKPI reports**

Which NT AHKPI reports do you use? (Please tick one or all options that apply)

Forty-six percent (6/13) of services use both the Community Health Centre (CHC) reports and the Health Service Delivery Area (HSDA) reports, 38% (5/13) use only the CHC report and 8% (1/13) use only the HSDA Report. One service did not respond to this question.

What do you find most useful in each of the report(s) that you use?

Seventy-eight percent (10/13) of respondents identified the most useful aspects of the CHC report and 69% (9/13) of the HSDA report. Data on trends over time were the most useful aspects of both reports. Additionally, for the HSDA report 23% (3/13) found the comparisons to the region and other services to be most useful.

What are the weaknesses of each of the report(s) that you use?

Fifty-three percent (7/13) of respondent identified weaknesses of the CHC report and 39% (5/13) of the HSDA report. Weakness of these reports include: aggregated and retrospective data, lack of context and missing data (‘does not cover 5-15-year-old school age children’ and ‘Some KPIs rely on a claiming GP’). One answer was difficult to interpret ‘confusion about STI data collection’.

How could the report(s) that you use be improved to make it more useful for: service planning, CQI, Other?

Eighty five per cent (11/13) of respondents answered this question for the CHC report, and 23% (3/13) for the HSDA report. Suggested improvements are shown in Table 6.
Table 6: Participant responses to question ‘How could the report(s) that you use be improved to make it more useful for: service planning, CQI, other’

<table>
<thead>
<tr>
<th>Community Health Centre Report</th>
<th>Health Service Delivery Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘More KPIs. More frequent reports e.g. quarterly’</td>
<td>‘More KPIs’</td>
</tr>
<tr>
<td>‘Improve accuracy. Add context. Condense. Summarize key findings and issues with a sort of executive report’</td>
<td>‘We break down some of the KPIs to be more meaningful’</td>
</tr>
<tr>
<td>‘We pretty much make the most of it as is’</td>
<td>‘Have it broken into the month’s that the activities occurred and we could then pinpoint the times when work decreases or occurs’</td>
</tr>
<tr>
<td>‘Have it broken into the months that the activities occurred and we could then pinpoint the times when work decreases or occurs’</td>
<td></td>
</tr>
<tr>
<td>‘Monthly’</td>
<td></td>
</tr>
<tr>
<td>‘Looking at adult immunisations including Hep B and fluvox’</td>
<td></td>
</tr>
<tr>
<td>‘Removed all of the blurb (add as an appendix) to shorten length of reports’</td>
<td></td>
</tr>
<tr>
<td>‘Perhaps community feedback data could be more appropriate’</td>
<td></td>
</tr>
<tr>
<td>‘Better training for people using the KPIs to improve data entry. Currently there is minimal training. There is good PCIS support but I think there are a lot of data entry errors and I don’t think everyone is included in the system. For example with childhood anaemia, people can fail to include them into the system’</td>
<td>‘Report can be very time consuming in its layout. Most clinicians only want trend reports and graphs’</td>
</tr>
<tr>
<td>‘I would like to see as much emphasis on the non-clinical KPIs, especially workforce-related KPIs but presently they seem more of an ‘optional extra’. They don’t pick up population program work at all, especially lifestyle matters like smoking, obesity and AOD, which is a pity’</td>
<td>‘If more frequent reports, there would be an opportunity to flag areas on the decline or receive reassurance that the team is on the “right pathway” to improving outcomes’</td>
</tr>
<tr>
<td>‘Have it broken into the months that the activities occurred and we could then pinpoint the times when work decreases or occurs’</td>
<td>‘Report can be very time consuming in its layout. Most clinicians only want trend reports and graphs’</td>
</tr>
<tr>
<td>‘Report can be very time consuming in its layout. Most clinicians only want trend reports and graphs’</td>
<td>‘If more frequent reports, there would be an opportunity to flag areas on the decline or receive reassurance that the team is on the “right pathway” to improving outcomes’</td>
</tr>
</tbody>
</table>
Results from the questionnaire to higher level planners

We received eight completed questionnaires from higher level planners. Their jobs and affiliations are listed in Table 7.

Table 7: Job roles and affiliations of respondents to questionnaire to higher level planners

<table>
<thead>
<tr>
<th>Job role of respondent</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associate Program Leader Health Promotion</td>
<td>NT DoH</td>
</tr>
<tr>
<td>CQI Facilitator</td>
<td>Did not state</td>
</tr>
<tr>
<td>Associate Program Leader Child Youth Health Strategy Unit</td>
<td>NT DoH</td>
</tr>
<tr>
<td>CQI Program Coordinator</td>
<td>AMSANT and steering committee</td>
</tr>
<tr>
<td>General Manager PHC services</td>
<td>NT DoH and steering committee</td>
</tr>
<tr>
<td>General practitioner</td>
<td>Congress Regional Health Services and steering committee</td>
</tr>
<tr>
<td>CQI Coordinator</td>
<td>Central Australian Aboriginal Congress</td>
</tr>
<tr>
<td>Communicare support</td>
<td>AMSANT and steering committee</td>
</tr>
</tbody>
</table>

In the following section, I first state the question as posed in the questionnaire and follow this with my assessment of the responses.

How do you use the NT AHKPIs?

All respondents answered this question. Eighty-five percent (11/13) use the reports for CQI and supporting services in their planning and 18% (2/11) can’t access the reports.

Do you use the NT AHKPIs for planning, policy development, CQI, Other (please specify)?

Sixty-three percent (5/8) of higher level planners use the indicators for planning, policy development, and CQI. One added under the ‘other’ option ‘Epidemiology - e.g. diabetes prevalence’. Thirteen percent (1/8) use them for planning and CQI. Twenty-five percent (2/8) selected the ‘other’ option and added:
- ‘If I did get these reports, I would use them for planning and policy development’
- ‘Not directly, only for support - in all of the above [planning, policy development, CQI]’.

Overall, most respondents (71%) found the indicators to be ‘very useful’ for planning, and CQI (80%), but less than half found them ‘very useful’ for policy development (Table 8). One participant selected other and added ‘Unable to access data other than through other’s presentations’.
Table 8: Responses from higher level planners to question 5 ‘How useful were the NT AHKPIs in assisting with planning, policy development, CQI, and other’

<table>
<thead>
<tr>
<th></th>
<th>Planning n (%)</th>
<th>Policy development % (n)</th>
<th>CQI % (n)</th>
<th>Other % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very useful</td>
<td>5 (71)</td>
<td>3 (43)</td>
<td>4 (80)</td>
<td></td>
</tr>
<tr>
<td>Somewhat useful</td>
<td>2 (29)</td>
<td>4 (57)</td>
<td>1 (20)</td>
<td></td>
</tr>
<tr>
<td>Not very useful</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not useful at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total responses</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**NT AHKPI reports and data**
Fifty percent (4/8) of higher level planners use both data and the reports, 25% (2/8) use only the reports, and 25% (2/8) selected the ‘other’ option and added:
- ‘I would like to if had easy access’
- ‘The reports are not distributed widely to our strategy unit area but would be valuable. They should be made more widely available’

Thirty-eight percent (3/8) of respondents use all three reports (CHC, HSDA and the de-identified HSDA reports). One uses the de-identified HSDA and CHC reports. Twenty-five percent (2/8) use only the de-identified HSDA report. One uses the CHC report and added: ‘Run reports from Communicare in between reporting periods to monitor progress’.

**Why do you choose this report? (Please answer for each that apply to you)**
Overall, the reports identify needs and show trends over time, however the HSDA report and the de-identified HSDA report provide comparisons with other regions.

**What do you find most useful about each of the report(s) that you use?**
Overall, respondents found the data on trends over time were the most useful aspects of all of the reports. Additionally, the CHC report ‘allows understanding and promotion at local level’, is ‘useful data format, relevant to service delivery’ and ‘well laid out and easy to read’, and additionally for the HSDA and de-identified HSDA reports, they provide a ‘NT wide picture’.
‘What are the weaknesses of each of the report(s) that you use?’
Half of the respondents provided information on what they identified as weaknesses of the NT AHKPI reports.
Weakness of the CHC report include: they lack context, small numbers, too much data and the data are ‘questionable’ with an ‘unclear population base’.

Weaknesses of the HSDA report include that they lack context, the calendar and financial year data are combined, and the data are aggregated and the weakness of the de-identified HSDA reports is that there is not enough detail.

How could the report(s) that you use be improved to make it more useful for Planning, Policy, CQI, other?
Overall, suggested improvements included identifying services, combining financial and calendar year exploring ways to eliminate patients being counted more than once and to have the data and reports more widely available.

How do you think the NT AHKPIs are being used at the service level?
All respondents answered this question. Overall, the KPIs are used for CQI, to measure performance for feedback to communities and to boards.

What factors do you think are promoting their use at the service level?
All respondents answered this question. Factors that were identified as promoting their use at the service level included: realising the value of the indicators, a need for reporting, CQI strategy and familiarity and usefulness of the data.

What factors do you think are hindering their use at the service level?
Seventy-five percent (6/8) of participants responded to this question. Overall, the factors identified as hindering use of the KPIs at the service level included: high staff turnover and lack of confidence in the quality of the data.

How do you explore variations you see in the NT AHKPIs over time (e.g. explore other data sources such as work force data or speak to the community or staff)?
Seventy-five percent (6/8) of respondents answered this question. Overall, higher level planners use other reports and datasets to try ‘to get a more complete picture’ as well as speaking to other health service staff or staff at AMSANT.
Once you have explored variations in the NT AHKPIs, how do you act on the findings to improve service performance and to make plans for the future?

Seventy-five percent (6/8) provided an answer to this question. Overall, to improve service planning, actions that are taken include: creating a ‘plan-do-study-act’ (PDSA) plan, talk to staff, train and mentor staff, health promotion activities and ‘a whole range of CQI activities’.

Are there any changes that could be made to the governance of the NT AHKPIs that would support continuous improvement of the system?

Thirty-eight percent (3/8) responded ‘yes’ and 68% (5/8) responded ‘don’t know’.

Overall, suggested changes included:
1. promoting the reports and making them more widely available;
2. improving the comparability between data from PCIS and Communicare; and
3. giving Communicare the ability to collect data across multiple clinics for one client.

Any other comments or suggestions you may have are welcome.

One person added ‘These reports are kept closely by some areas and are not shared. They would be valuable to inform planning and policy development, and program management that I know of - but I am sure would have other applications if we had access to the information. These reports need to be shared more widely’. 
Discussion
To address the objectives of the evaluation, we chose two key approaches: 1) to evaluate each indicator and 2) assess the usefulness of the system as expressed by key stakeholders drawing on surveys of all people who use the indicators at the PHC level and of higher level planners. I will discuss the findings from these two approaches separately.

Indicators evaluated against OECD criteria
Importance of the KPIs and can the health care system meaningfully address the disease area
With the exception of KPI 1, the KPIs assess important disease areas that policy makers are concerned about, and that are part of the core functions of PHC for Aboriginal and Torres Strait Islanders in the NT. Although each of the disease areas has their own unique challenges to delivery, they are also influenced by a range of social and environmental health determinants, many of which go beyond the domain traditionally covered by PHC services. Culturally appropriate, family centred approaches, engagement with communities and working collaboratively across the continuum of care (74), support to address local factors and good disease guidelines are needed for primary health care to be successful in addressing all of these disease areas (75).

Scientific soundness of the KPIs
Overall, the quality of the data that inform the KPIs is good and has improved substantially since the system was first introduced. NT DoH conducts systematic checks to validate the data before distributing the summary reports to services and higher level planners. However, these checks do not identify incomplete or incorrect data entries.

No information is collected on the variability of diagnostic testing devices used to inform some of the KPIs (e.g. Hemocue to screen for anaemia by testing Hb levels). It could be worth considering collecting this information so that comparability of the testing device that inform some of the KPIs across services could be assessed.

Changes have been made to either the numerator and/or denominators definitions for 13/16 KPIs since the system was first introduced which affects the reliability of these
KPIs over time. However, these changes have been fully documented and are available on the NT AHKPI website to enable meaningful interpretation of the trends.

It is not possible to assess completeness of the data because zero reporting is not used and the significance of blank numerator cells remains unknown. However, the proportion of services reporting no data (no numerator and denominator data) has improved substantially since the system was first introduced.

The value of nine of the 16 indicators is supported by good scientific evidence to support 9/16 KPIs, however, of these, 3 KPIs (low birth weight babies, underweight children and anaemic children) are outcome indicators that are highly influenced by a range of environmental and socioeconomic factors and can therefore not be used as a valid reflection of the performance of a PHC service.

Seven of the 16 KPIs measure the proportion of resident clients who have been screened/tested for an abnormality; they capture provision of services but not the remedial action taken once a problem was identified. Collecting information on how these abnormal findings are managed is the first step to understanding whether action is ‘appropriate’.

**How the indicators are meeting their intended goals**

*Inform understanding of trends in individual and population health outcomes*  
The KPIs describe trends and this is cited as being one of the most important aspects of the NT AHKPI reports, however they do not inform understanding of trends. This requires data to be collected on the social and environmental determinants related to health conditions being measured. Participants make up for this by exploring variations in trend data through speaking with their staff and with the community, and cross referencing with other reports.

*Identify factors influencing these trends*  
The same applies to this objective. The indicators do not meet this objective because they do not provide any contextual information, or provide any information on the social and environmental determinants of health associated with the measured disease areas. As stated by one of the respondents ‘They provided limited information on a
small range of indicators. To really understand what is happening from a CQI perspective you usually have to get further data to really explore the situation. However, that is the nature of indicators - I don’t think it would be good to too many KPIs or too complex data reports’. To identify factors influencing these trends, respondents explore other sources of information such as exploring other datasets, and speaking to staff and the community. This has also been reported by a previous evaluation which found that the indicators are not generally used for CQI on their own (134).

‘Inform appropriate action, planning and policy development’
The results show that the indicators are used to inform action, and planning and to a lesser degree policy development. All services reported using the KPIs for either service planning and CQI. All higher level planners (who have access to the KPIs) use the KPIs to support services in their planning and CQI. These findings are consistent with a previous study that evaluated the CQI Quality Improvement Investment Strategy (134).

Whether the action is ‘appropriate’ cannot be determined through this evaluation or through the indicators because no information is collected on how problems are addressed once they are identified. For example, with regard to KPI 6 (proportion of children tested for anaemia and who are anaemic), information should also be collected on whether anaemic children were treated and how they were treated. The OECD state that providing screening tests is a ‘process measure of quality’ that has construct validity when the screening test is linked to earlier detection of disease and a better prognosis (11). The following KPIs (2, 3, 5, 6, 8.1, 8.2, 9, 10, 11, 12, and 13) do allow for earlier detection of disease, however, the action taken by the individual and the health worker is what will make a difference to the prognosis, and make a difference to the health status of that individual and the community.

Are the NT AHKPIs being used for other purposes
A major use of the indicators has been for CQI of PHC services (134). This has been previously reported but is not stated in the system’s original goals. In addition to this, they are also used to motivate staff.
How can the reports and processes be improved?

Overall, condensing the reports whilst providing them on a more frequent basis and disaggregating the results so they can be used more ‘operationally’ are suggestions for how the reports can be improved. These suggestions reflect the busy environment in PHC. The NT AHKPI data appear to be a valuable, useful source of information for people at the PHC level, however as stated by one respondent, there is ‘too much data’. Providing an executive summary at the beginning of each of the reports, reducing the overall content of each of the reports, while providing them more frequently may further improve the system.

Limitations

This evaluation is subject to multiple biases and I have categorised these in terms of selection and measurement biases.

Measurement bias

- The major source of measurement bias for this study is my interpretation of the open-ended responses from the participants. Interpreting answers is subjective and my interpretation may have introduced my own ideas about the indicators.
- Even though we piloted the questionnaire, they were not validated. The way we worded the questions may have also introduced bias into the study.

The effect of these biases is uncertain.

Selection bias

- Our very small response rate means our findings are not generalizable to the source population.
- By conducting the survey online, we may have excluded services located in remote areas where internet access can be limited. Although I did try to counteract this by taking hard copies of the questionnaires with me to CQI Collaborative Workshop, and by giving participants the option to complete the questionnaire with me over the telephone.
- By sending the questionnaires to services via the CEOs of the services, the questionnaires may not have reached all staff. In the original study proposal, we had included visiting a sample of services which would have reduced this selection bias but due to time constraints this could not be done.
Conclusion

Findings from the questionnaires revealed that the KPIs are considered a very valuable tool being used to inform planning of PHC services, but information on whether the action and planning is ‘appropriate’ is not collected. The results of KPIs cannot address objectives 1 and 2 (‘inform understanding of trends in individual and population health outcomes’ and ‘identify factors influencing these trends’) because data aren’t collected on the social and environmental determinants related to the health conditions and events being measured.

The response rate for our study was very small and therefore unlikely to be representative of the study population of health staff related to the PHC services. This limits us from being able to draw meaningful or generalizable conclusions or recommendations until in-depth interviews and focus group discussions can be conducted with all relevant staff. We need more robust evidence to assess whether the indicators are addressing their intended goals effectively, and how the system could be improved for greater usefulness.
Recommendations

* I have shared initial findings with stakeholders and they requested that I continue to collect questionnaire data to collect stronger more meaningful evidence. This study is therefore still a work in progress and recommendations are still to be developed with the stakeholders in line with UFE guidance.

Recommendations based on assessment using OECD criteria

1. Introduce KPIs that assess the quality of treatments and services to determine if action is ‘appropriate’.

2. Use zero reporting so that there is a clearer understanding of what is a missing value and what is a zero.

3. Consider removing or modifying objectives 1 ‘inform understanding of trends in individual and population health outcomes’ and 2 ‘identify factors influencing these trends’ from the overarching goals of the NT AHKPI system. These objectives go beyond what KPIs are able to do.

Recommendation based questionnaires

4. Continue collecting questionnaires to collect stronger, more meaningful evidence that can help to further strengthen the system.

5. Conduct focus groups with higher level planners to understand how the KPIs are used for the development of policy and how they might be improved to make them more useful.

6. Condense the reports, provide an executive summary at the beginning of the reports and provide them more frequently.

7. Consider making the reports more widely available to all NT DoH and AMSANT staff.
Appendix 1: List of the Northern Territory Aboriginal Health Key Performance Indicators (NT AHKPls) as at December 2015

1. Number of episodes of health care and client contacts*.
2. Timing of first antenatal visit for regular clients delivering Indigenous babies.
3. Number and proportion of low, normal and high birth weight Indigenous babies.
4.1. Number and proportion of Indigenous children fully immunised at 1, 2 and 6 years of age.
4.2. Proportion of children who have received immunisations on time.
5. Number and proportion of children less than 5 years of age who are underweight.
6. Number and proportion of children between 6 months and 5 years of age who are anaemic.
7. Number and proportion of clients aged 15 years and over with type 2 diabetes and/or coronary heart disease who have a chronic disease management plan.
8.1. Number and proportion of resident clients aged 15 years and over with type 2 diabetes who have had a glycosylated haemoglobin (HbA1c) test in the last 6 months.
8.2. The number and proportion of Indigenous clients with type 2 diabetes and whose HbA1c measurements are within certain levels.
9. Number and proportion of diabetic patients with albuminuria who are on Angiotensin Converting Enzyme Inhibitor (ACE) inhibitor and/or Angiotensin Receptor Blocker (ARB).
10. Number and proportion of Indigenous clients aged 15 to 55 years who have had a full adult health check.
11. Number and proportion of Indigenous clients aged 55 years and over who have had a full adult health check in the past 12 months.
12. Number and proportion of women who had had at least one Papanicolaou (PAP) smear test during reporting period.
13. Number and proportion of Indigenous clients who have type 2 diabetes and who have good blood pressure (BP) control within a 6 month period.
14. Number and proportion of Indigenous Acute Rheumatic fever (ARF)/ Rheumatic Heart Disease (RHD) patients who are prescribed to be requiring 2-4 weekly Benzathine Penicillin G (BPG) penicillin prophylaxis and have received 80% of their injections over a 12 month period.
Appendix 2: Modified criteria to select indicators to monitor health care quality against which KPIs will be assessed from Health Care Quality Indicators Project - Conceptual Framework Paper, 2006 (11)(11)

1. Importance of what is being measured

- Impact of disease or risk on health and on health expenditure. What is the impact on health and on health expenditure associated with each disease, risk or client group? To help understand these impacts, the OECD has prepared a list of conditions with the highest costs, morbidity, and mortality. Preferably, the measure will address areas in which there is a clear gap between the actual and potential levels of health that can be influenced by improvements in the quality of care.

- Policy importance. Are policy makers and consumers concerned about the disease or risk group area?

- Susceptibility to being influenced by the health care system. Can the health care system meaningfully address this disease area or problem? The measure should reflect an aspect of health that can be influenced by the health care system as it exists or as it is envisioned. That is, policy makers can take specific actions (generally at the structural or process level) to improve health care in that area and, ultimately, health status. Injuries caused by automobile accidents, for example, are the leading cause of death among young adults, but most remedies (for example, changing car design or reducing the speed limit) lie outside the influence of the health care sector.

2. Scientific soundness of the measure

- Validity. Does the measure actually measure what it is intended to measure? The measure should make sense logically and clinically (face validity); it should correlate well with other measures of the same aspects of the quality of care (construct validity) and should capture meaningful aspects of the quality of care (content validity) (Carmine and Zeller, 1991; Nunnally, 1978). In general, measures should be linked to significant processes or outcomes of care as demonstrated by scientific studies. For example, the provision of selected screening tests in a timely manner is a process measure of quality that has construct validity when the screening is linked to earlier detection of disease and a better prognosis or outcome. Outcome measures should be examined for validity in a similar manner.

- Reliability. Does the measure provide stable results across various populations and circumstances? The measure should produce consistent results when repeated in the same populations and settings, even when assessed by different people at different times. Measurement should reflect changes in the subject of measurement rather than from artefacts of measurement (for example, a change in the definition of the measure or, for rare events, restricted sample size or small numbers of cases). This aspect is particularly important for periodic data collection. Most measures will have to be repeated every year, and any changes in the measure should reflect a true change in quality.

- Explicitness of the evidence base. Is there scientific evidence available to support the measure? There should be a clearly documented scientific foundation for the measure in the literature. An explicit evidence base could also mean that there is some other specific, formal process by which the measure has been accepted as a valid marker for quality, such as review by an expert panel.

* Feasibility of obtaining internationally comparable data criterion has been removed
Appendix 3: Participant information sheet as it appeared on SurveyMonkey, 2015

Evaluation of the NT AHKPIs

Participant Information Sheet

Thank you for agreeing to participate in this survey and taking the time to complete this questionnaire to contribute to further strengthening of the Northern Territory Aboriginal Health Key Performance Indicators (NT AHKPIs). This questionnaire is part of an evaluation of the NT AHKPIs that I am conducting as a project in the Master of Applied Epidemiology Program in collaboration with the NT AHKPI steering committee.

The objective of this evaluation is to assess the extent to which the NT AHKPIs are addressing their intended goals and to determine whether they are being used for other purposes. We want to determine: (a) how useful you find the community and health service delivery reports sent to you by the Northern Territory Department of Health; (b) how you are using the NT AHKPIs to inform, planning and actions at your service; (c) how the processes and reports could be improved and made more useful for your health service.

The questionnaire will take around 10 minutes to complete. You may complete it online or over the phone with me on (02) 5289 5907 or by hand and then fax back to me on (02) 5289 5911. We understand that you are busy and we appreciate whatever information you are able to provide us.

The results from this survey will be compiled as a report for the NT AHKPI steering committee, Aboriginal Medical Service Alliance of the Northern Territory (AMSANT), Northern Territory and Commonwealth Departments of Health at the end of this year, to inform ongoing strengthening of the NT AHKPI system. We will provide you with a summary of key findings from the report and will not distribute it to any other individual or agency. The survey participants will NOT be identified in the report, and you can refuse at any time to participate in the survey.

This project has been approved by the Menzies School of Health Research Ethics Committee, the Central Australian Human Research Ethics Committee, AMSANT, the Australian National University (ANU) Ethics Committee, the Northern Territory and Commonwealth Departments of Health and the NT AHKPI steering committee.

If you have any concerns or questions regarding the evaluation, please contact either:

Myself on (02) 5289 5907 or at anna-lena.arnold@health.gov.au

ANU ethics on (02) 6125 3427 or at human.ethics.officer@anu.edu.au

Menzies School of Health Research Ethics Committee at ethics@menzies.edu.au

Thank you again for the time you are taking to complete this questionnaire.

Yours sincerely,

Anna-Lena Arnold
Master of Philosophy in Applied Epidemiology (MAE) Scholar
Evidence and Evaluation Section
Indigenous Health Division
02 5289 5907 | Anna-Lena.Arnold@health.gov.au
Appendix 4: Participant consent form as it appeared on SurveyMonkey, 2015

Title: Evaluation of the Northern Territory Aboriginal Health Key Performance Indicators (NT AHKPIs)

Short Title: Evaluation of the NT AHKPIs

Principal Investigator: Arna-Lena Arnold

Associate Investigators: Associate Professor Mohamed Patel, Rachel Meyer

This questionnaire is part of an evaluation of the NT AHKPIs that I am conducting as a project in the Master of Applied Epidemiology Program in collaboration with the NT AHKPI steering committee. This project has been approved by the Menzies School of Health Research Ethics Committee, the Central Australian Human Research Ethics Committee, AMSANT, NT and Commonwealth DoH and the NT AHKPI steering committee.

Declaration by Participant

1. I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

2. I understand the purposes, and procedures of the research described in the project.

3. I have had an opportunity to ask questions and I am satisfied with the answers I have received.

4. I freely agree to participate in this project to evaluate the NT AHKPIs as described and understand that I am free to withdraw at any time during the project without any future repercussions.

5. Please type participant name

6. Please type name of interpreter (if applicable)

7. It would be very useful for us if you provided the name of your service. However, we understand if you do not want to.

If you are willing, please provide the name of your service/clinic here:

Prev  Next
Appendix 5: Questionnaire for primary health care services as it appeared on SurveyMonkey, 2015

Evaluation of the NT AHKPIs

8. What is your job role at your organisation?

9. How do you or your service use the NT AHKPIs?

10. What value do you see to the NT AHKPIs?

11. Do you use the NT AHKPIs for:
   - [ ] Service Planning
   - [ ] CQI
   - [ ] Feedback to communities
   - [ ] Other (please specify)

12. Please list examples of how you use the NT AHKPIs for each of the options that are applicable to you
   - Service planning
   - CQI
   - Feedback to communities
   - Other

13. How useful were the NT AHKPIs in assisting with:

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<th>Somewhat useful</th>
<th>Not very useful</th>
<th>Not useful at all</th>
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</table>
14. What other sources of data do you use for service planning and CQI?

15. Which NT AHKPI report(s) do you use? (Please tick one or all options that apply)
   - Community Health Centre Report
   - Health Service Delivery Area Report
   - Other (please specify)

16. How do you explore variations you see in the NT AHKPIs over time? (e.g. explore other data sources such as workforce data or speak to the community or staff?)

17. What do you find most useful in each of the report(s) that you use?
   - Community Health Centre Report
   - Health Service Delivery Report
   - Other

18. What are the weaknesses of each of the report(s) that you use?
   - Community Health Centre Report
   - Health Service Delivery Report
   - Other

19. How could the report(s) that you use be improved to make it more useful for:
   - Service planning
   - CQI
   - Other

20. Any other comments or suggestions you may have are welcome.
Appendix 6: Questionnaire for higher level planners as it appeared on SurveyMonkey, 2015

Evaluation of the Northern Territory Aboriginal Health Key Performance Indicators

Questionnaire

6. What is your job role at your organisation?

9. How do you use the NT AHKPIs?

10. Do you use the NT AHKPIs for:
    □ Planning
    □ Policy development
    □ ODI
    □ Other (please specify)

11. Please list examples of how you use the NT AHKPIs for each of the options that are applicable to you
    Planning
    Policy development
    ODI
    Other

12. How useful were the NT AHKPIs in assisting with:
    □ Very useful
    □ Somewhat useful
    □ Not very useful
    □ Not useful at all
    Planning
    Policy development
    ODI
    Other (please specify)

13. Do you use the NT AHKPI data or NT AHKPI reports?
    □ Data
    □ Reports
    □ Data and reports
    □ Other (please specify)

14. Which NT AHKPI report(s) do you use? (Please tick one or all options that apply)
    □ Community Health Centre Report
    □ Health Services Delivery Report
    □ De-identified Health Service Delivery Report
    □ None
    □ Other (please specify)
Questionnaire

15. Why do you choose the report? (Please answer for each that apply to you)
   Community Health Centre Report
   Health Service Delivery Report
   De-identified Health Service Delivery Report
   Other (please specify)

16. What do you find most useful about each of the report(s) that you use?
   Community Health Centre Report
   Health Service Delivery Report
   De-identified Health Service Delivery Report
   Other

17. What are the weaknesses of each of the report(s) that you use?
   Community Health Centre Report
   Health Service Delivery Report
   De-identified Health Service Delivery Report
   Other

18. How could the report(s) that you use be improved to make it more useful for:
   Planning
   Policy
   Operations
   Other
   Other

19. How do you think the NT AHIKPs are being used at the service level?

20. What factors do you think are promoting their use at the service level?

21. What factors do you think are hindering their use at the service level?
22. How do you explore variations you see in the NT AHKPIs over time? (e.g., explore other data sources such as workforce data or speak to the community of staff?)

23. Once you have explored variations in the NT AHKPIs, how do you act on the findings?
   - To improve service performance
   - To make plans for the future

24. Are there any changes that could be made to the governance of the NT AHKPIs that would support continuous improvement of the system?
   - Yes
   - No
   - DON'T KNOW

25. If yes, please list what changes could be made.

26. Any other comments or suggestions you may have are welcome.
Appendix 7: Advertisement for evaluation of the NT AHKPIs as it appeared in the online Communicare newsletter

Evaluation of the Northern Territory Aboriginal Health Key Performance Indicators (NT AHKPIs)

From the Department of Health

An evaluation of the NT AHKPIs is currently underway! In collaboration with the NT AHKPI steering committee including the NT Department of Health, and AMSANT, we are conducting a project to find out how the NT AHKPIs are being used, and how the processes and reports could be improved and made more useful. This project has been approved by the relevant ethics, the Australian Department of Health and the NT AHKPI steering committee. We want to hear from anyone who uses the NT AHKPIs. To participate in this survey you can go to this link: https://www.surveymonkey.com/r/NTAHKPI_PHG, or contact me on 02 6239 5587 to complete the survey over the phone with me. The survey takes only 10 minutes to complete and will contribute to further strengthening of the NT AHKPIs.

The results from this survey will be compiled as a report to the NT AHKPI steering committee, NT Department of Health and AMSANT to inform ongoing strengthening of the NT AHKPI system. We will provide you with a summary of key findings and will not distribute it to any other individual or agency. The survey participants will NOT be identified in the report and you can refuse to participate at any time.

We would be grateful to hear from as many of you as possible. If you have any questions or comments, please don’t hesitate to contact me on 02 6239 5587 or at Anna-Lena.Arnold@health.gov.au

We look forward to hearing from you!

Thank you.

Anna-Lena Arnold
Master of Philosophy in Applied Epidemiology (MAE) Scholar
Evidence and Evaluation Section
Indigenous Health Division
02 6239 5587 | Anna-Lena.Arnold@health.gov.au
Appendix 8: Presentation I gave on the NT AHKPI evaluation at the CQI collaborative in Darwin, 10-11 November 2015

EVALUATION OF THE NORTHERN TERRITORY ABORIGINAL HEALTH KEY PERFORMANCE INDICATORS

Anna Lena Arnold
Master of Applied Epidemiology student
Indigenous Health Division, Commonwealth
Department of Health
The Australian National University

Presentation Outline
- Basics of the NT AHKPIs
- How are we evaluating?
- What do we know so far?
- What do we need to do next?

Goals of the NT AHKPIs
- "Improves understanding of trends in individual and population health outcomes;"
- "Identifies factors influencing these trends; and"
- "Informs appropriate action, planning and policy development."

Aims of the evaluation
- To find out whether the KPIs are:
  - meeting intended goals
  - how else they are being used
  - how to improve

How are we evaluating?
- Mixed method design
  - Questionnaires
  - Primary Health Care
  - Administrative records
- Document and literature review
  - OECD standards for evaluating KPIs

How are we evaluating? - Questionnaires
- PHC services
  - How are the KPIs being used
  - Value
  - Improvements
  - Variations in data
  - Other sources of data
- Higher level planners
  - Policy
  - Governance
Chapter 3

How are we evaluating? - OECD criteria

1. Importance of what is being measured
2. Impact of disease on health and expenditure
3. Policy importance
4. Susceptibility to being influenced

Scientific soundness of the measure
1. Validity
2. Reliability
3. Interpretation

Progress

- Surveys sent to:
  - Aboriginal Community Controlled Health Organisations
  - Northern Territory Government Services
- 5 completed HIC surveys
- 5 completed surveys from higher level planners
- 5 out of the 15 KPIs reviewed using OECD criteria

What do we know so far?

- KPIs very useful for service planning and QOI
- How they are used:
  - Monitoring staff
  - Identifying gaps
  - Format reporting
  - Indicate areas that need attention
  - Measuring goals
  - Promoting progress towards and outstanding work
  - Trends over time most useful

What do we need to do next?

- Keep going - get more surveys!
- Please participate

Conclusion

- NT KPIs developed to improve Aboriginal health in the NT
- Tool developed to evaluate how the KPIs are doing
- KPIs useful but excellent ideas on how to make even better
- We want to know more!

Participate! take our survey!
Acknowledgements
- NT AHKPI steering committee
- AMSANT
- Special thanks to Liz Moore, Margaret Cotter, Kerry Copley, Maryanne Leman
- NT DEH
- Special thanks to Christine Connors
- Australian Department of Health

CECD criteria
1. Importance of what is being measured which includes:
   1. The impact of disease or risk on health and health expenditure
   2. Policy importance
   3. Suitability to being monitored by the health care system
2. Scientific soundness of the measure which includes:
   1. Validity
   2. Reliability
   3. Equitableness

Methodology to find out how are the KPIs doing
- Questionnaire to higher level planners:
  - How KPIs used at service level
  - Factors promoting and/or hindering
  - How the participants use the findings
  - Governance
Appendix 9: Feedback from the pilot of the questionnaires

A clinic coordinator: ‘I think survey was good asking how useful the NTKPI were and what we used them for also the weakness and how they could improve them’. 

Data Integrity/Medicare Claims Coordinator: ‘I have completed the survey today and find no problems with the questions etc’. 

Director of Director of Medical Services, Primary Health Care: ‘I have looked at the version for Primary Health Care services. Overall, I think it is a nicely designed survey. There is some useful information at the beginning, and the survey content and length are fine. Some of the questions ask for comments (e.g., questions 8, 9, 11, 15, 16, 17, 18). It would be a good idea to allow multi-line edit boxes for these questions. There doesn’t seem to be a limit to the number of characters when you type into the boxes provided. However, it is difficult to keep track of your answer, as less than 60 characters are visible at a time’.  

Another comment: ‘The dedicated CQI/kpi enthusiasts will be more than happy to write in boxes. The less enamored would probably prefer boxes just to tick’. 

District Manager: ‘Not too onerous, no, but I’m with X in terms of the tick-a-box format being more attractive to someone with multiple tasks and responsibilities on their mind’. 

General Manager: ‘It doesn’t look too onerous, but having said that how many staff are likely to complete it???’.
References

27. Scott J. Chronic disease profiles in one high risk Indigenous community: a comparison of chronic disease profiles after a 10 year follow up and the relationship between birth weight and chronic disease morbidity and mortality: The University of Queensland; 2014.


74. NHMRC. Strengthening Cardiac Rehabilitation and Secondary Prevention for Aboriginal and Torres Strait Islander Peoples: A Guide for Health Professionals. NHMRC: Canberra, 2005.
82. Baker IDI. diabetes: the silent pandemic and its impact on
Chapter 3

103. Harris M. The role of primary health care in preventing the onset of chronic disease, with a particular focus on the lifestyle risk factors of obesity, tobacco and alcohol. Sydney: Centre for Primary Health Care and Equity, UNSW 2008.
Chapter 4 - Screening and managing anaemia in Aboriginal and Torres Strait Islander children aged 6 months to 3 years in the Northern Territory, 2008 -2013

‘Three areas are critical foundations for healthy child development: stable, responsive, and nurturing caregiving with opportunities to learn; safe, supportive, physical environments; and appropriate nutrition.’ Margaret Chan, Director-General, World Health Organization (1)

MAE requirement: Epidemiological Study
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Preface

Investigatory role
As lead investigator for this project I designed the study, prepared the applications to ethics committees, requested and analysed the data, interpreted and compiled the findings, and reported the results to stakeholders.

Lessons learnt
I learnt that it can take a long time to access de-identified electronic medical record data. We first requested the data in February of 2015 and received the final dataset in mid-November 2015. The application process was lengthy, complex, and at times confusing, but I received great support from NT DoH through the application process for which I am thankful.

I learnt that data collected for administrative purposes rather than research can be limited in terms of completeness, validity and usefulness, but they can still provide a rich source of information to inform health programs and policy meaningfully.

Through this project I also learnt how to manage, structure and merge large datasets with multiple observations per record in Stata.

Potential public health impact
This study provides evidence that the prevalence of anaemia among children aged 6 months to 3 years attending NT DoH services between 2008 and 2013 is a ‘severe’ public health problem, as defined by WHO, and that there is a need to improve the screening and management of anaemia in children, while providing culturally appropriate nutritional education and access to healthy food.

These findings will be disseminated to primary health care clinic staff and presented at other fora such as the annual Continuous Quality Improvement (CQI) anaemia Collaboration, and the Annual Practical Paediatrics conference, to convince decision-makers and clinicians to change practise as a high priority.
Acknowledgements
I acknowledge the following people for their assistance, support and guidance with this project:

- Heather Ferguson, Northern Territory Department of Health
- Dr Therese Kearns and Linda Ward at Menzies School of Health Research
- Rachel Meyer, Hope Peisley, and Dr Masha Somi, the Indigenous Health Division, Australian Government Department of Health
- Dr Emily Fearnley and Associate Professor Mahomed Patel, the Australian National University
**Abbreviations**

<table>
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<tr>
<th>Abbreviation</th>
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<tr>
<td>ARIA</td>
<td>Accessibility/Remoteness Index of Australia</td>
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<tr>
<td>ABCD</td>
<td>Audit and Best Practice for Chronic Disease</td>
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<td>CARPA</td>
<td>Central Australian Rural Practitioners Association</td>
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<td>CQI</td>
<td>Continuous Quality Improvement</td>
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<td>DoH</td>
<td>Department of Health</td>
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<tr>
<td>g</td>
<td>Grams</td>
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<tr>
<td>g/L</td>
<td>Grams per litre</td>
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<tr>
<td>Hb</td>
<td>Haemoglobin</td>
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<td>HUSK</td>
<td>Healthy Under 5 Kids Program</td>
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<td>Primary Health Care</td>
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<td>Standard deviation</td>
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<td>WHO</td>
<td>The World Health Organization</td>
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Abstract

Introduction
Anaemia remains a persistent health challenge for Aboriginal and Torres Strait Islander children in the Northern Territory (NT). The latest data from the 2014 NT Aboriginal Health Key Performance Indicators (NT AHKPIs) revealed that 22% of Aboriginal and Torres Strait Islander children aged 6 months to 5 years tested for anaemia, were anaemic (unpublished NT AHKPI data, 2015) with little change over the last five annual reporting periods, ranging between 22% and 28%. According to the categories defined by the World Health Organization (WHO), this is a public health problem that must be addressed effectively. Reports of Continuous Quality Improvement (CQI) Program of the ‘Audit and Best Practice for Chronic Disease’ (ABCD) National Partnership indicate that best practice guidelines for the management of anaemia are poorly implemented in NT primary health care (PHC) services. We aimed to assess how well the guidelines recommended by the Central Australian Rural Practitioners Association (CARPA) for the management of anaemia among children aged 6 months to 3 years attending NT Department of Health (DOH) were being implemented by PHC services.

Methods
NT DoH extracted and de-identified medical electronic record data for Aboriginal and Torres Strait Islander children aged 6 months to 3 years attending NT DoH services between 2008 and 2013. Data were forwarded to me in five separate Excel spreadsheets within the same Excel file. I imported the data into Stata, cleaned and reshaped the data and merged the files as a one-to-one merge matching on the ‘Child Person ID’ and ‘Result Date’ variables. I produced frequency tables to show the demographic profile of the cohort, and the number and proportion of children who were anaemic. I cross tabulated categorised Hb levels based on the guidelines recommended by CARPA with the Accessibility/Remoteness Index of Australia (ARIA), age group and treatment. I used the Pearson’s chi-squared test to determine statistically significant differences between binary and categorical variables. Results were considered significant if P-values were < 0.05.
Results
Sixty-three percent (3,475/5,543) of children were screened for anaemia at least once during the study period. The median age when Hb was first tested was 12 months (range 6 to 37 months). At the time of first screening, 40% (1,394/3,475) of children were anaemic. Seven percent (256/3,475) had an Hb < 90 g/L and 2.5% (87/3,475) had an Hb < 80 g/L. The prevalence was highest in children aged 6 - 11 months, and decreased with increasing age. The prevalence of anaemia was highest in ‘very remote’ areas and decreased with decreasing remoteness. Twenty-one percent (290/1,394) of anaemic children had records of treatment with albendazole and the median duration of treatment was for 3 days (range 0 to 8 days). Less than 1% (13/1,394) of anaemic children were recorded to have been treated with iron. Only 23% (325/1,394) of anaemic children were followed up at or within 4 weeks of diagnosis.

Conclusion
The prevalence of anaemia among children aged 6 months to 3 years attending NT DoH services between 2008 and 2013 is a ‘severe’ public health problem, as defined by WHO. The prevalence was highest amongst children aged 6-11 months as may have been expected, and in ‘very remote’ areas, suggesting inadequate access to, and intake of, iron rich foods required to support rapid growth during this stage of life.

Although, based on the data collected, a very low proportion of anaemic children were recorded as treated according to best practice guidelines, our findings are subject to multiple potential biases described under the ‘limitations’ section.
Introduction

Background

What is anaemia?
Anaemia is a condition in which the number of red blood cells and/or haemoglobin (Hb) concentration is inadequate to meet the physiological needs of the body (2). These needs vary by age, gender, residential elevation above sea level, smoking behaviour, and pregnancy status (3).

The major cause of anaemia worldwide is iron deficiency anaemia (IDA), (4, 5) and other causes include:

1. nutritional deficiencies such as folate, vitamin A, and vitamin B_{12} deficiencies (leading to impaired red blood cell production) (3);
2. acute and chronic inflammation e.g. infections of childhood, end-stage renal disease and cancer (leading to red blood cell destruction and/or impaired red blood cell production/impedes release of stored iron) (3);
3. parasitic infections (leading to blood loss and/or impaired red blood cell production) (3);
4. inherited or acquired blood disorders (leading to impaired red blood cell production and/or excessive red blood cell destruction) (3);
5. blood loss from trauma/injury (6).

Types and causes of anaemia in the Northern Territory
Peer-reviewed publications reporting the types of anaemia among children in the NT are limited and obsolete with the last publication in 1994 (7-9). Results from these studies are consistent with global trends where IDA was the major cause of anaemia (7-10) (Table 1). In the NT, IDA in children has been attributed to one or more of the following causes: maternal anaemia before and during pregnancy, late introduction and insufficient intake of iron-rich solids in breastfed children, low birth weight, recurrent infections and intestinal worms (11).
Table 1: Peer-reviewed publications on causes of anaemia in Aboriginal and Torres Strait Islander children in the NT (7-9)

<table>
<thead>
<tr>
<th>Author (publication)</th>
<th>Year</th>
<th>Location</th>
<th>Study population</th>
<th>Cause of Anaemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crotty (7)</td>
<td>1958</td>
<td>Katherine</td>
<td>n=28 aged 7 months-6 years</td>
<td>Iron and protein deficiency</td>
</tr>
</tbody>
</table>
| Watson (8)           | 1986 | Yirrkala, East Arnhem land      | n=47 aged ≥ 5 years | • 74% of cases caused by iron deficiency - attributed partly (no proportion given) to hookworm infestation and the remainder caused by nutritional deficiencies  
  • 11% caused by folate deficiency  
  • 4% iron and folate deficiency  
  • 11% unknown |
| Walker (9)           | 1994 | NT-based hospital study         | 25% of children admitted to hospital (number not stated) | Iron deficiency                                                          |
Prevalence of Anaemia in the Northern Territory

Anaemia remains a persistent health concern for Aboriginal and Torres Strait Islander children in the NT. The latest data available from the NT Aboriginal Health Key Performance Indicators (AHKPIs) in 2014 revealed that 22% of Aboriginal and Torres Strait Islander children aged 6 months to 5 years tested for anaemia were anaemic (unpublished 2015 NT AHKPI data), with little change over the last five annual reporting periods, ranging from 22% to 28% (Figure 1).

Figure 1: The proportion of Aboriginal and Torres Strait Islander children aged 6 months - 5 years tested and recorded as anaemic in the NT from 2010 - 2014 (unpublished 2015 NT AHKPI data)

The Healthy Under Five Kids (HU5K) study reported that 30% (491/1629) of Aboriginal and Torres Strait Islander children aged 0-3 years attending NT Department of Health (DOH) Primary Health Care (PHC) services in 2012 were anaemic (12). The World Health Organization (WHO) defines a prevalence of anaemia ≥ 40.0% as a ‘severe public health problem’, a prevalence of 20.0-39.9% as a ‘moderate public health problem’, a prevalence

1 The NT AHKPI data are collected from all 84 primary health care services [both Northern Territory Government and Aboriginal Community Controlled Health Organisations (ACCHOs)] across the NT

2 The HU5K program is a schedule of visits at key age milestones for children aged 0-5 years. This involves routine collection of measurements of weight; height/length and haemoglobin. The program is designed to provide a consistent platform of care, support and information for parents, to address key determinants of child health. The overall aim of the program is to improve the growth and nutritional status of children in the NT.
of 5.0-19.9% as a ‘mild public health problem’ and a prevalence of ≤ 4.9% as ‘normal’ (13).
Based on these criteria, the prevalence of anaemia in children aged 0-3 years in the NT is a ‘moderate’ public health problem that must be addressed.

Evidence of the impact of anaemia on cognitive and other developmental pathways

Anaemia or IDA have adverse effects on many aspects of child health including cognitive, behavioural and physical development, as well as immune function (13-15). Most studies investigating the health impacts of anaemia have focused on IDA. There is a large body of research that shows anaemia and IDA have adverse effects on many areas of child health including: cognitive, physical and social development, the immune system, and on homeostatic responses (Appendix 1). Animal studies have also shown that other adverse effects such as increased heavy-metal absorption (16), or impaired thyroid function (17) can also occur as a result of iron deficiency. The bulk of these studies have focused specifically on exploring the impact of anaemia and IDA on cognitive development and as a result there is strong evidence that anaemia and IDA are associated with poorer cognitive development in infants, preschool and school-aged children (18, 19). If anaemia or IDA is left untreated, developmental delays can persist into adulthood to impact on work and economic productivity (20). But whether IDA is the only cause of cognitive impairment remains unclear. Owing to the large number of socioeconomic and environmental disadvantages (poverty, low birth weight, malnutrition poor education among mothers, lack of stimulation at home) that are often associated with anaemia and can themselves affect children’s development, a causal link between anaemia and these adverse health outcomes is yet to be fully established because of the difficulty to be able to control for all of these factors in study designs (18, 21).

Some animal studies have provided a number of possible mechanisms through which iron deficiency can affect the developing brain (22-25), such as through hypo-myelination (reduced amount of myelin in spinal cord, brain, or peripheral nerves) or delayed neuro-maturation (26), but overall, the exact biological mechanisms behind the relationship between anaemia and IDA and cognitive development remain relatively unclear. Lozoff (1998) states that when trying to determine the cause of anaemia and IDA, a conceptual model of contributing factors must include environmental as well as biological determinants as these mechanisms are not mutually exclusive (27, 28).
Management of anaemia in the Northern Territory

In the NT, low birth weight (<2,500g) and pre-term babies are first screened for anaemia at one month of age (11). For children with a birth weight of > 2500g who are not premature, screening commences at six months of age and continues every six months to five years of age (11). For children who are anaemic but who have a Hb of ≥ 90g/L, treatment with iron and albendazole (where hookworm is common - in the Top End of NT, north of Ti Tree (11)) is recommended with follow up at 4 weeks. For children with Hb < 90 g/L, treatment with iron, folic acid and albendazole are recommended, as well as a full blood examination, medical review and follow-up (Table 2).

<table>
<thead>
<tr>
<th>Result</th>
<th>What it means</th>
<th>What to do</th>
</tr>
</thead>
</table>
| Low for age but Hb level 90g/L or more | ‘Likely to be iron deficient’ | -Give iron orally or by injection  
-Where hookworm infestation is common – give albendazole for 3 days  
-Follow-up  
-If Hb < 100 g/L – medical review |
| Hb < 90g/L at any age | “May be other cause of anaemia” (other than IDA) | -If Hb < 80g/L – medical consult straight away  
-Treat as above AND give folic acid  
-Full blood examination  
-Medical review  
-Follow up |

‘Encourage healthy eating and diet high in iron for strong blood’

CQI reports of the ABCD National Partnership indicate that best practice guidelines for management of anaemia are poorly implemented (29, 30). These reports incorporate data from NT, Queensland (QLD), South Australia (SA), Western Australia (WA), and New South Wales (NSW) for children aged < 6 years.

**Aims**

The aim of this study was to assess how well the best-practice guidelines recommended by CARPA for screening and management of anaemic Aboriginal and Torres Strait Islander children aged 6 months to 3 years the NT were being implemented.
Methods

Study population
Our study population was Aboriginal and Torres Strait Islander children aged 6 months to 3 years attending at least one of the 52 NT DoH PHC services that have electronic records recorded in Primary Care Information System (PCIS). This age group was chosen because the prevalence of anaemia is usually highest in this age group (12, 31-34) and decreases with increasing in age (35).

We had originally intended to include infants aged < 6 months in this analysis. However, Hb is not tested routinely in this age group except for children with a birth weight < 2,500g as they are ‘likely to become iron deficient’ (11) in their first 6 months. CARPA recommends a medical review for this age group as well as giving iron from one to six months of age (11). At the time of data extraction, NT DoH advised that data for gestational weight in PCIS were of ‘very poor quality’ and recommended we request data from the Perinatal National Minimal Dataset and link them with the PCIS data from NT DoH. This process required amendments to our original ethics applications and we received this advice too late to re-apply for ethics approval. Infants aged < 6 months were therefore excluded from this analysis.

Only data from health services managed by NT DoH were included in this analysis because they use the same PCIS and we required approval from only five general manager executives for 52 NT DoH services. ACCHOs use a different patient information system (Communicare). Furthermore, to extract data from the 32 ACCHOs, we required approvals from each of the 32 individual services. Owing to time constraints, we decided to focus our study only on NT DoH services.

The years 2008 and 2013 were selected because most PHC services only started using the PCIS in 2008. A map showing the distribution of PCIS PHC services is shown in Appendix 2.
Chapter 4

Data sources

Primary Care Information System medical electronic data

NT DoH extracted and de-identified medical electronic record data from 2008 to 2013 from the PCIS for 52 PHC NT DoH services across the NT and forwarded them to me via email in a password protected Excel Spreadsheet. Demographic details and results of Hb, full blood examination (FBE), weight, height/length and treatment details were sent in five separate Excel spreadsheets within the same Excel file. The variables from NT DoH and the variables used in this analysis are shown in Appendix 3.

I imported the Excel spreadsheets into Stata and saved the files as separate Stata data files. I cleaned and checked the data for errors and duplicates using descriptive analyses to summarise the data using ‘Codebook’ ‘Summarize’ ‘Describe’ ‘Duplicates Report’ and ‘Duplicates List’. I checked outliers and erroneous data with supervisors in the NT (who are familiar with the datasets) for a decision to be made on whether these data should be included or excluded. I dropped duplicates. I reshaped the data from long to wide format so that the data could be merged. I merged Hb test results for the cohort’s first screening visit to the demographic data as a one-to-one merge, matching on the ‘Child Person ID’ variable. I calculated the age of the children by subtracting the PCIS birth date from the first Hb visit date. I created categorised Hb levels based on the CARPA Guidelines (Table 3). To determine how many anaemic children received treatment, I merged the treatment data (variables are listed below) with the Hb test results and demographic data using a one-to-one merge matching on ‘Child Person ID’ and ‘Result Date’ (after renaming ‘Dose start date’ to ‘Result date’ so that the variables could be merged) (Figure 2). The ‘Dose duration’ variable had 39% (2,916/7,564) missing data, so I created a new variable for dose duration by subtracting ‘Dose End Date’ from ‘Dose Start Date’. CARPA defines areas north of Ti Tree in the NT as locations were hookworm is common (11). Services north of Ti Tree were coded accordingly to identify the proportion of children receiving albendazole in these areas.
Figure 2: The datasets consisting of de-identified electronic medical record data sent by NT DoH that were merged using a one-to-one merge for the analysis. Variables that were matched on are highlighted by the red boxes.

Table 3: Diagnosis of anaemia by age groups using the Central Australian Rural Practitioners Association Guidelines

<table>
<thead>
<tr>
<th>Age group</th>
<th>Anaemia if haemoglobin (g/L) is less than</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-11 months</td>
<td>105</td>
</tr>
<tr>
<td>1 – 4 years</td>
<td>110</td>
</tr>
<tr>
<td>5 - 7 years</td>
<td>115</td>
</tr>
<tr>
<td>8 – 11 years</td>
<td>119</td>
</tr>
<tr>
<td>12 – 15 years (male)</td>
<td>125</td>
</tr>
<tr>
<td>12 – 15 years (female)</td>
<td>118</td>
</tr>
</tbody>
</table>

* The age group relevant to this study is highlighted by the red box.

The Accessibility/Remoteness Index of Australia

I used The Accessibility/Remoteness Index of Australia (ARIA) based on the road distance from a point or place to the nearest service centre (36) (Table 4). I categorised PHC services accordingly.

Table 4: Accessibility/Remoteness Index of Australia (ARIA) categories

<table>
<thead>
<tr>
<th>ARIA category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly accessible</td>
<td>‘Relatively unrestricted accessibility to a wide range of goods and services and opportunities for social interaction’</td>
</tr>
<tr>
<td>Accessible</td>
<td>‘Some restrictions to accessibility of some goods, service and opportunities for social interaction’</td>
</tr>
<tr>
<td>Moderately accessible</td>
<td>‘Significantly restricted accessibility of goods, services and opportunities for social interaction’</td>
</tr>
<tr>
<td>Remote</td>
<td>‘Very restricted accessibility of goods, services and opportunities for social interaction’</td>
</tr>
<tr>
<td>Very remote</td>
<td>‘Very little accessibility of goods, services and opportunities for social interaction’</td>
</tr>
</tbody>
</table>
**Statistical analyses**

I produced frequency tables to show the demographic profile of the cohort and the number and proportion of anaemic children. I cross tabulated categorised Hb levels based on the CARPA guidelines with ARIA, age group and different types of documented treatment types. I used the Pearson’s chi-squared test to determine statistically significant differences between binary and categorical variables. Results were considered significant if P-values were < 0.05.

**Ethics**

I obtained ethics approvals from:

1. The Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research (HREC-2015-2340)
2. The Central Australian Human Research Ethics Committee (HREC-15-291)
3. The Australian National University Human Research Ethics Committee (2015/313)
4. NT DoH

**Results**

Electronic medical record data were available for 5,543 children aged 6 months to 3 years. Of these, 98.7% (n=5,469) were Aboriginal, 1% (n=59) were Aboriginal and Torres Strait Islander and 0.3% (n=15) were Torres Strait Islanders.

Of 52 services, three were ‘moderately accessible’, eight were ‘remote’ and 41 were ‘very remote’. Twenty-four services were located north of Ti Tree.

**Screening for anaemia**

Sixty-three percent (3,475/5,543) of children were screened for anaemia at least once. The median age when Hb was first tested was 12 months (range 6 to 37 months).

**Prevalence of anaemia**

At the time of first screening, 40% (1,394/3,475) of children were anaemic. The prevalence was highest in children aged 6-11 months, and decreased with increasing age (Table 5).
Table 5: Prevalence of anaemia among Aboriginal and Torres Strait Islander children aged 6 months to 3 years attending NT DoH services at first screening, by age groups, 2008-2013

<table>
<thead>
<tr>
<th>Age groups</th>
<th>No. tested and % with anaemia</th>
<th>No. tested and % with Hb &lt; 90 g/L</th>
<th>No. tested and % with Hb &lt; 80 g/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-11 months</td>
<td>734 (53%)</td>
<td>178 (70%)</td>
<td>63 (72%)</td>
</tr>
<tr>
<td>12-23 months</td>
<td>462 (33%)</td>
<td>68 (27%)</td>
<td>19 (22%)</td>
</tr>
<tr>
<td>24-37 months</td>
<td>198 (14%)</td>
<td>10 (3.9%)</td>
<td>5 (5.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>1394</td>
<td>256</td>
<td>87</td>
</tr>
</tbody>
</table>

1 Anaemia defined as haemoglobin <105 g/L in children aged 6 months to 12 months and haemoglobin <110 g/L in children aged 12 months - <5 years

The prevalence of anaemia was highest in ‘very remote’ areas and decreased with decreasing remoteness (Table 6). The numbers were too small to draw any meaningful conclusions for moderate and severe anaemia (Tables 7 and 8).

Table 6: Prevalence of anaemia among Aboriginal and Torres Strait Islander children aged 6 months to 3 years attending NT DoH services at first screening, by Accessibility/Remoteness Index of Australia (ARIA), 2008-2013

<table>
<thead>
<tr>
<th>ARIA</th>
<th>Anaemic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes n (%)</td>
<td>No n (%)</td>
</tr>
<tr>
<td>Moderately accessible</td>
<td>34 (25%)</td>
<td>100 (75%)</td>
</tr>
<tr>
<td>Remote</td>
<td>145 (30%)</td>
<td>334 (70%)</td>
</tr>
<tr>
<td>Very Remote</td>
<td>1,215 (42%)</td>
<td>1,647 (58%)</td>
</tr>
<tr>
<td>Total</td>
<td>1,394</td>
<td>2,081</td>
</tr>
</tbody>
</table>

χ² (2) = 38, P = <0.01

Table 7: Prevalence of ‘moderate’ anaemia among Aboriginal and Torres Strait Islander children aged 6 months to 3 years attending NT DoH services at first screening, by Accessibility/Remoteness Index of Australia (ARIA), 2008-2013

<table>
<thead>
<tr>
<th>ARIA</th>
<th>Anaemic &lt; 90 g/L at any age</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes n (%)</td>
<td>No n (%)</td>
</tr>
<tr>
<td>Moderately accessible</td>
<td>7 (5.2%)</td>
<td>127 (95%)</td>
</tr>
<tr>
<td>Remote</td>
<td>19 (4.0%)</td>
<td>460 (96%)</td>
</tr>
<tr>
<td>Very Remote</td>
<td>230 (8.0%)</td>
<td>2,632 (92%)</td>
</tr>
<tr>
<td>Total</td>
<td>256</td>
<td>3,219</td>
</tr>
</tbody>
</table>

χ² (2) = 11, P = 0.004
Table 8: Prevalence of ‘severe’ anaemia among Aboriginal and Torres Strait Islander children aged 6 months to 3 years attending NT DoH services at first screening, by Accessibility/Remoteness Index of Australia (ARIA), 2008-2013

<table>
<thead>
<tr>
<th>ARIA</th>
<th>Anaemic &lt; 80 g/L at any age</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes n (%)</td>
<td>No n (%)</td>
</tr>
<tr>
<td>Moderately accessible</td>
<td>2 (1.5%)</td>
<td>132 (98.5%)</td>
</tr>
<tr>
<td>Remote</td>
<td>5 (1.0%)</td>
<td>474 (99%)</td>
</tr>
<tr>
<td>Very Remote</td>
<td>80 (2.8%)</td>
<td>2,782 (97%)</td>
</tr>
<tr>
<td>Total</td>
<td>87</td>
<td>3,388</td>
</tr>
</tbody>
</table>

χ² (2) = 5.7, P = 0.057

Management compared with the Central Australian Rural Practitioners Association guidelines

Anaemic children with Hb ≥ 90g/L should be treated with iron and albendazole (where hookworm is common) and have a follow-up Hb test 4 weeks later. Duration of treatment with albendazole should be for 3 days (11). Duration of treatment with iron depends on the weight of the child (not assessed in this analysis). For anaemic children with Hb < 90 g/L, treatment with iron, folic acid and albendazole are recommended, as well as a full blood examination, medical review and follow up (11) (Table 9).

Less than 1% (13/1,394) of anaemic children were recorded to have been treated with iron (Table 9). Only 20% (290/1,394) of anaemic children had a record of treatment with albendazole and the median duration of treatment was 3 days (range 0 to 8 days) (Table 9). But only 12% (163/1,394) were recorded to have had albendazole for 3 days (Table 10). Of the children living in areas where hookworm is ‘common’ 28% (233/824) were treated with albendazole. Of those who had a follow up visit and Hb test at or within 4 weeks, all (n=325) were still anaemic.
Table 9: Proportion of Aboriginal and Torres Strait Islander anaemic children aged 6 months to 3 years attending NT DoH services treated according to Central Australian Rural Practitioners Association (CARPA) Guidelines, 2008-2013

<table>
<thead>
<tr>
<th>Haemoglobin (Hb) result</th>
<th>Central Australian Rural Practitioners Association (CARPA) Guidelines</th>
<th>Documented treatment n (%)</th>
<th>Treatment not documented n (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low for age but Hb level ≥ 90 g/L</td>
<td>Give iron medicine oral or intramuscular injection</td>
<td>13 (0.93%)</td>
<td>1,381 (99%)</td>
<td>1,394</td>
</tr>
<tr>
<td></td>
<td>Where hookworm is common – give albendazole for 3 days</td>
<td>3 days</td>
<td>163 (12%)</td>
<td>1,104 (79%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>290 (21%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow-up at 4 weeks</td>
<td>325 (23%)</td>
<td>1,069 (77%)</td>
<td>1,394</td>
</tr>
<tr>
<td></td>
<td>If Hb &lt; 100g/L – medical review</td>
<td></td>
<td></td>
<td><em>Data not available to assess this</em></td>
</tr>
<tr>
<td>Hb &lt; 90 g/L at any age</td>
<td>If Hb &lt; 80g/L – medical consult straight away</td>
<td></td>
<td></td>
<td><em>Data not available to assess this</em></td>
</tr>
<tr>
<td></td>
<td>Give iron medicine oral or intramuscular injection</td>
<td>3 (1.2%)</td>
<td>253 (98.8%)</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td>Where hookworm is common – give albendazole for 3 days</td>
<td>3 days</td>
<td>9 (3.5%)</td>
<td>186 (73%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>70 (27%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Give folic acid</td>
<td>29 (11%)</td>
<td>227 (89%)</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td>Full blood examination</td>
<td></td>
<td></td>
<td><em>Dates of full blood examination result do not match haemoglobin test result dates so one-to-one merge was not possible as part of this analysis</em></td>
</tr>
<tr>
<td></td>
<td>Medical review</td>
<td></td>
<td></td>
<td><em>Data not available to assess this</em></td>
</tr>
<tr>
<td></td>
<td>Follow-up at 4 weeks</td>
<td>89 (35%)</td>
<td>167 (65%)</td>
<td>256</td>
</tr>
</tbody>
</table>
Table 10: Duration of albendazole treatment for anaemic children, 2008-2013

<table>
<thead>
<tr>
<th>Duration of albendazole treatment (days)</th>
<th>No. (%) of children treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>89 (32%)</td>
</tr>
<tr>
<td>1</td>
<td>1 (0.36%)</td>
</tr>
<tr>
<td>2</td>
<td>20 (7%)</td>
</tr>
<tr>
<td>3</td>
<td>163 (58%)</td>
</tr>
<tr>
<td>4</td>
<td>1 (0.36%)</td>
</tr>
<tr>
<td>6</td>
<td>3 (1.07%)</td>
</tr>
<tr>
<td>7</td>
<td>1 (0.36%)</td>
</tr>
<tr>
<td>8</td>
<td>3 (1.07%)</td>
</tr>
<tr>
<td>Total</td>
<td>281</td>
</tr>
</tbody>
</table>

*Data on ‘DoseEndDate’ missing for nine children so dose duration could not be calculated

Management of children with haemoglobin < 90 g/L

Overall, 1% (3/256) were treated with iron and only 27% (70/256) were treated with albendazole. The median duration of treatment with albendazole was 2 days (range 0 to 8 days) (Table 9). Of the children living in areas where hookworm is ‘common’ 36% (52/146) were treated with albendazole. Ninety-two percent (236/256) had a follow-up visit, however only 35% (89/256) were seen within or at 4 weeks (Table 9). Of those who had a follow-up visit and Hb test within or at 4 weeks, 61% (54/89) still had Hb < 90g/L.

Management of children with haemoglobin < 80 g/L

For children with Hb < 80 g/L, 93% (81/87) had a follow up visit, however only 40% (35/87) were followed up within or at 4 weeks of being diagnosed with anaemia, and of these 27% (22/81) were still anaemic at the time of their second visit.
Discussion

The early identification and management of anaemia are essential to prevent the long term consequences of anaemia particularly during early years of development. This study provides further evidence of the high prevalence of anaemia among Aboriginal and Torres Strait Islander children in the NT, and some evidence that a high proportion of these anaemic children are not being managed according to CARPA Guidelines, however these findings need to be validated.

The prevalence of anaemia

The prevalence of anaemia is very high among Aboriginal and Torres Strait Islander children aged 6 months to 3 years attending NT DoH services. Although the prevalence (40%) was slightly lower than the estimated global average (47%) (37), it is a ‘severe’ public health problem as defined by WHO (38).

It is not possible to compare our findings with other studies in the NT because of differences in age group, physical location of the study participants, and due to the temporal differences in data collection. However, our findings are consistent with a study conducted in six remote communities (four in the NT, one in QLD and one in the East Kimberley region in WA) conducted between 2010 and 2012. In that study 44% (n=73) of children aged 0-24 months, and 56% (n=91) aged between 6 and 9 months, were anaemic (39). In another study conducted on a smaller cohort (n=398) of Aboriginal infants aged 6 months to 12 months living in northern NT, 68% (n=398) were anaemic (40).

The prevalence of anaemia in our study is higher than that reported in the NT AHKPI data (range 22% -28% between 2010 and 2014). While the latter include children aged 6 months to 5 years attending both NT governed DoH services and ACCHOs, our results refer only to children aged 6 months to 3 years attending NT DoH services.

The prevalence of anaemia in our study is higher than the prevalence reported by the HU5K program in 2012 when 37% of children aged <12 months, 28% of children aged 1 to < 3 years, and 16% of children aged 3 to < 5 years were anaemic. It is possible this difference in prevalence could be related to a different study period and the fact that HU5K also draws on data from non-government organisations who agreed to be part of
that program (details for these organisations are not given in the relevant published reports (12).

Consistent with previous findings (12, 32-34), the prevalence of anaemia was highest amongst children aged 6 to 11 months and decreased with increasing age. The 6 - 24 month age group represents the peak prevalence of iron deficiency in children (31) when there is a higher need for iron due to rapid growth (10, 33, 34, 41). By 6 months, neonatal iron stores start to deplete and complementary iron rich foods (among other nutrients) are needed for rapid growth (42, 43). Major causes of IDA in this age group are the delayed introduction of solid iron rich foods and exclusive consumption of low-iron milks such as cow, goat’s or soy milk (44). The prevalence decreases with decreasing rate of growth over time and lowered iron requirements. These findings highlight the importance of access to education, good nutrition and effective clinical screening and management. A study of one remote community in the NT showed that parental knowledge of anaemia and the importance of good nutrition was good but this knowledge was not put into practice by parents. Reasons for this must be explored among all communities in the NT. It is critical not only to treat children in this age group effectively for anaemia but also to close the gap in the health inequalities between Aboriginal and Torres Strait Islander Australians and non-Indigenous Australians (45).

It’s promising to hear that as part of the 2014-2015 Federal Budget, $95 million over three years from July 2015 has been allocated to a program called ‘Better Start to Life’ which includes identifying and targeting funding to increase Aboriginal and Torres Strait Islander families’ access to advice and assistance with breastfeeding, nutrition and parenting, and monitoring development milestones (46). Hopefully this funding will help improve nutritional status of these children but the failure to effectively screen and manage anaemic children based on CARPA must also be addressed.

The prevalence of anaemia was highest in ‘very remote’ areas and decreased with decreasing remoteness. These findings are consistent with results from the ‘2012-2013 Australian Aboriginal and Torres Strait Islander Health Survey’ where (10.1% in remote compared to 6.9% in non-remote areas) (47). Poor supply of nutritious food contributes to poor nutrition and diseases such as anaemia, particularly in remote Australia (48).
Although these results were for adults aged ≥ 18 years, the causes for this disparity are likely to be the same. These findings further highlight the need for improved access to and education on good nutrition.

**Screening for anaemia**
All children in this group should have been screened for anaemia but only two-thirds were screened. This is lower than that reported in the NT AHKPIs (overall 72% for 2013 and range between 22% to 100% for individual services, unpublished 2014 data) and in the HUSK data (70%). It is possible that this difference could be related to the differences in the study designs mentioned in previous section.

**Treatment of anaemia**
Less than 1% of anaemic children were treated with iron supplements, only 28% of children living in areas where hookworm is common were treated with albendazole, and only 23% had a follow-up Hb test within 4 weeks. According to a smaller study on 398 Aboriginal children aged 6 to 12 months in northern NT in 2013, 20% of mothers of anaemic children were given dietary advice, 27% of anaemic children were administered a complete course of albendazole, 30% treated with a complete course of iron, and 28% did not receive any iron treatment. A follow-up Hb was checked in 60% of anaemic children and 26% of infants with Hb <90g/L received folate (40).

In an audit of electronic medical record data of Aboriginal children aged < 6 years attending PHC services in NT, QLD, SA, WA and NSW in 2007, 22% (range 0-100) of children had a Hb test, 39% (range 0-100) of anaemic children were treated with albendazole, 48% (range 0-100) had an iron supplement prescription, and 47% (range 0-100) had a follow up Hb assessment (29).

Our findings are of extreme clinical and public health concern and must be confirmed. If our findings are correct, this is a major public health concern as defined by the WHO. Previously reported barriers to treatment include high staff turnover; fragmented models of care and staff poorly prepared for their roles (40), inappropriate guidelines (not just CARPA guidelines, refers to jurisdictional guidelines for ‘Far West’ NSW, QLD, NT, SA and WA) that compromise the systematic approach to screening and case finding, (49) and varied knowledge of health practitioners about the frequency and severity anaemia in
children and its potential consequences in children (50). These barriers must be addressed as a high priority.

**Limitations**

This study is based on an analysis of electronic medical record data entered into PCIS in the course of providing clinical care to children; and are therefore subject to multiple potential biases. The study therefore lacks internal validity (the extent to which the results are truly representative of the study population) and cannot be generalised to the source population (51). I have categorised these biases in terms of selection and measurement biases.

**Measurement bias**

Measurement bias is an error in the estimate of frequency or association arising from a systematic error in the measurement of the exposure or outcome factor (51). The data reflect only what was documented in the electronic patient record; it is therefore possible that misclassification of ‘outcome/anaemia’ and ‘exposure/treatment’ and variables may have biased the results i.e. under or overestimated the prevalence of anaemia and/or the frequency of effective management:

**Misclassification of the ‘outcome/anaemia’ variable**

- Children may have been recorded as anaemic based on an incorrect low result from the diagnostic device used to measure Hb levels. This would overestimate the proportion of children with anaemia. In a similar way, if the diagnostic device gave an incorrectly high Hb result, this would underestimate the prevalence of anaemia. The haemoglobinometers have been used to screen for anaemia as part of routine practice in the NT for the past 30 years. Currently the HemoCue haemoglobinometer is used (52). The HemoCue has a reasonable sensitivity (85%) and specificity (94%) in detecting anaemia (10, 53), and the sensitivity is reported to reach 100% in controlled laboratory conditions (54). However, the reproducibility, accuracy and precision of the HemoCue results are highly dependent on the conditions under which the test has been conducted in the clinic, whether venous or capillary blood had been collected and whether the HemoCue products were stored in appropriate storage conditions, particularly in humid climates (55, 56). It is not possible to quantify the effect of this potential
bias on our findings because I have no knowledge of the quality control procedures used by the multiple clinics for the HemoCue.

- My coding in Stata could have incorrectly classified children as being anaemic. However, I checked my coding with a senior researcher at the Menzies School of Health Research, so this bias is therefore unlikely.

**Misclassification of the ‘age variable’ affecting the outcome**

- It is possible a child’s date of birth may have been incorrectly entered, thus affecting the estimation of the age-specific prevalence of anaemia. It is not possible to know how likely this bias is without further investigations.

**Misclassification or the ‘treatment/exposure’ variable**

- Treatment may have been recorded and entered into the wrong section of the medical electronic record and therefore wasn’t extracted by NT DoH for this analysis. Personal communication from a senior staff member from Menzies School of Health Research advised that clinical data (including treatment data) are often written in the ‘notes’ section of the electronic medical record and not where the data should be entered. This bias is likely to have under-estimated the treatment frequency in our analysis.

- Treatment may have been given correctly but was not recorded in the electronic medical record. Personal communication from a staff member at NT DoH advised that the treatment data were ‘messy’. This bias is also likely to have under-estimated the treatment frequency.

- The treatment may have not been given correctly, but was recorded as being given. This could overestimate the true frequency of treatment. It is not possible to know how likely this bias is without further investigations.

- Treatment may have been prescribed but was not administered by the parents. This could overestimate the true frequency of treatment. Similarly, the parents may have administered the treatment but this was no recorded in the electronic medical record. This will have underestimated the true frequency. It is not possible to know how likely this bias is without further investigations.

**Selection bias**

Selection bias is an error in the estimate of frequency or association arising from the manner in which subjects are selected from the sampling frame into the study population.
Our source population was children attending NT DoH services, our sampling frame (database population) was the children entered into PCIS database, and our study population were all children recorded to have anaemia (Figure 3). Through these different stages of selection, it is possible that we may have included and/or excluded children incorrectly where the study population may not be truly representative of the sampling frame and therefore of the source population i.e. the denominators for assessing prevalence of anaemia or the frequency of treatment may be biased. The study may not be generalizable to the sampling frame and/or source population if:

- Not all children attending NT DoH services had a record on PCIS - this affects the size of the denominator population.
- Children were incorrectly included or excluded into the study based that would affect the size of the denominator population. This may either under- or over-estimate the prevalence of anaemia.
- All children are screened for anaemia, but clinicians may preferentially screen children considered more likely to be anaemic i.e. biased selection of children with anaemia which could overestimate the prevalence of anaemia.
- It is possible that not all data on children entered into PCIS were extracted and included in the Excel files sent to me - this reduces the denominator population. This may either under- or over-estimate the prevalence of anaemia.
- By merging datasets one-to-one using the variable ‘Result Date’ I excluded children who were treated the day after, or a few days after from the analysis - this will underestimate the proportion of children were treated. This could be one explanation for why the proportion of anaemic children being treated is so low.

**Changing eligibility over time**

The case definition for anaemia and the recommended treatment has remained the same from 2008 to 2013 (11).
Other limitations

I could not assess the extent to which all CARPA guidelines on the management of anaemia were addressed by the PHC services. I could not assess how many anaemic children had a medical review after the initial diagnosis, a full blood examination or received dietary advice because the relevant data were not included in the dataset forwarded to me. Due to long delays in receiving the data, I was unable to review individual records to assess the dose and duration of treatments in time for submitting my thesis.

Use of non-parametric tests

A limitation of this study is that I used non-parametric tests to identify statistically significant differences in the analysis. According to Kirkwood and Sterne (57), non-parametric tests can lack power compared to parametric tests, particularly when working with small sample sizes. However, our sample size was relatively large for most estimates except for assessing children with ‘moderate’ and ‘severe’ anaemia categorised by ARIA. It was inappropriate to use parametric tests as the data were not normally distributed.
Conclusions

The prevalence of anaemia among children aged 6 months to 3 years attending NT DoH services between 2008 and 2013 is a ‘severe’ public health problem, as defined by WHO. The prevalence was highest amongst children aged 6 -11 months as may have been expected, and in ‘very remote’ areas suggesting inadequate access to, and intake of, iron rich foods required to support rapid growth during this stage of life.

Although, based on the data collected, a very low proportion of anaemic children were recorded as treated according to best practice guidelines, our findings are subject to multiple potential biases described under the ‘limitations’ section.
Recommendations

Our recommendations, detailed below, include: the need to validate the study results, assess barriers to implementing CARPA Guidelines, train health staff to improve data entry and patient management, and conduct culturally appropriate health promotion activities to improve nutrition in the community.

1. Validate study results
   a. Check that the findings from this study are based on valid data, i.e. that they are not due to selection or measurement biases inherent in analysing administrative data. One example for doing this is by studying a random sample of records from NT DoH services to assess the validity of the data used in the analysis.

2. Assess barriers to implementing CARPA guidelines
   a. If the findings are confirmed, conduct a systematic study with staff from PHC services (both ACCHOs and NT DoH) to assess reasons for low frequency of screening and of managing children consistent with CARPA guidelines.

3. Train health staff to improve data entry and patient management
   a. Refresher training on PCIS for staff from PHC services to improve data entry and the quality and validity of electronic medical records.
   b. Refresher training on anaemia and CARPA Guidelines to improve management for each individual case.

4. Conduct culturally appropriate health promotion activities to improve nutrition in the community
   a. Educate communities around anaemia and its serious long term consequences.
   b. Conduct a systematic study with both communities and practitioners from PHC services to find a culturally appropriate and sustainable way of improving the diets for these young Aboriginal and Torres Strait Islander children.
Appendix 1: Human studies showing the health and behavioural impacts of anaemia and iron-deficiency anaemia by age and location (non-exhaustive list)

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>0-15 months</th>
<th>6-12 months</th>
<th>12-24 months</th>
<th>2-5 years</th>
<th>5-8 years</th>
<th>8-11 years</th>
<th>11-15 years</th>
<th>&gt; 15 years</th>
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<tbody>
<tr>
<td>Poor cognitive development</td>
<td>Chile (58)</td>
<td>Guatemala (61)</td>
<td>Costa Rica (62-65), Chile; (66), Guatemala (61)</td>
<td>Indonesia (67)</td>
<td>India (68)</td>
<td>Thailand (69)</td>
<td>Thailand (69), India (68)</td>
<td>USA (71)</td>
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<tr>
<td>Poor psychomotor development</td>
<td>Chile (58), (72), USA (60)</td>
<td>Chile (59), (72), Japan (10-14 months) (73)</td>
<td>UK (74), Costa Rica (28), UK (75)</td>
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<tr>
<td>Poorer speech development</td>
<td>Japan (73)</td>
<td>Japan (73)</td>
<td>Japan (73)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poorer attention</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Behavioural disturbances</td>
<td>Japan (76)</td>
<td>Costa Rica (64)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Alterations in sleep wake cycle</td>
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<td></td>
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<td>USA (77)</td>
<td>USA (77)</td>
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<td>Impaired immune system</td>
<td>Chile (78)</td>
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<tr>
<td>Impaired temperature</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Impaired growth</td>
<td></td>
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</tbody>
</table>

References:
- Chapter 4
Appendix 2: Primary health care services in the Northern Territory by patient information recall systems
Appendix 3: Variables sent from the Northern Territory Department of Health

Datasets used in this analysis

Demographic data (6,658 unique records)

<table>
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<th>Variable</th>
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<tbody>
<tr>
<td>Child Person ID</td>
<td>Yes</td>
</tr>
<tr>
<td>PCIS Birth Date</td>
<td>Yes</td>
</tr>
<tr>
<td>Indigenous Status Description</td>
<td>Yes</td>
</tr>
<tr>
<td>Midwives Birth Gestational Age</td>
<td>No, because NT DoH warned data were of very poor quality and advised us to obtain this information from the Perinatal National Minimal Dataset but time did not allow for this</td>
</tr>
<tr>
<td>Midwives Birth Weight</td>
<td>No, because NT DoH warned data were of very poor quality and advised us to obtain this information from the Perinatal National Minimal Dataset but time did not allow for this</td>
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Haemoglobin data (26,458 records – 4,590 unique records)

<table>
<thead>
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<th>Used in this analysis?</th>
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</thead>
<tbody>
<tr>
<td>Child Person ID</td>
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</tr>
<tr>
<td>Service Clinic Name</td>
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</tr>
<tr>
<td>Result Date</td>
<td>Yes</td>
</tr>
<tr>
<td>Result Definition</td>
<td>Yes</td>
</tr>
<tr>
<td>Result Component</td>
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</tr>
<tr>
<td>Result Measure</td>
<td>Yes</td>
</tr>
<tr>
<td>Result Unit</td>
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</table>

Medications (7,564 records – 3,154 unique records)

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<tbody>
<tr>
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<tr>
<td>Dose Start Date</td>
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</tr>
<tr>
<td>Dose End Date</td>
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</tr>
<tr>
<td>Medication</td>
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</tr>
<tr>
<td>Minimum Dose</td>
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<tr>
<td>Dose Unit</td>
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</tr>
<tr>
<td>Dose Duration</td>
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</table>
Datasets not used in this analysis

Full blood examination data (6,484 records - 345 unique records)

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<td>Result Definition</td>
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<tr>
<td>Result Measure</td>
<td>No</td>
</tr>
<tr>
<td>Result Unit</td>
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</tbody>
</table>

*Not included in this analysis owing to time constraints. Merging datasets as a one-to-one merge was not possible because ‘Result Date’ from Hb dataset does not match ‘Result Date’ from this dataset and there are multiple records per child. More time needed to sort out these data.

Weight (110,517 records – 5,911 unique records)

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<tbody>
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<td>Result Date</td>
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<td>Result Measure</td>
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</tr>
<tr>
<td>Result Unit</td>
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</tbody>
</table>

*These data were going to be used to assess different growth patterns between anaemic children receiving best practice care compared and those who didn’t, but owing to time constraints this analysis was not possible to do in time for submission of the bound volume.

Height and length (26,673 records – 4,888 unique records)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Used in this analysis</th>
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<tr>
<td>Service Clinic Name</td>
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<tr>
<td>Result Component</td>
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<tr>
<td>Result Measure</td>
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</tr>
<tr>
<td>Result Unit</td>
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</tbody>
</table>

*These data were going to be used to assess different growth patterns between anaemic children receiving best practice care compared and those who didn’t, but owing to time constraints this analysis was not possible to do in time for submission of the bound volume.
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Chapter 5.1 - An unusual cluster of cases of *Ralstonia* bacteraemia from 1 April to 26 June 2014, in three states in Australia

*MAE course requirement*: Outbreak Investigation
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Preface
On 1 May 2014, the Therapeutic Goods Administration (TGA) was notified of three cases of *Ralstonia* bacteraemia from two different hospitals in South Australia (SA). Initial investigations carried out by the SA Department of Health (DoH) revealed that one or two batches of Provive propofol were the only common exposure between the three cases. On 2 May 2014, the TGA quarantined the two implicated batches of propofol, released a statement (Appendix 1) advising health professionals to avoid using Provive propofol and another product, Sandoz 1%, that was manufactured at the same site as the Provive. In response to the TGA’s announcement, between 5 and 8 of May 2014, a further four cases of *Ralstonia* bacteraemia were reported by the Queensland (QLD) DoH and one from the Victorian (VIC) DoH. All cases had received Provive propofol 1% solution. On 9 May 2014, the TGA initiated a multijurisdictional epidemiological investigation to assess the possibility of a causal association between the administration of propofol and *Ralstonia* bacteraemia, and to identify possible sources of contamination.

On 8 May 2014, Associate Professor Martyn Kirk sent an email to all Master of Applied Epidemiology (MAE) scholars placed in Canberra informing us of this suspected multijurisdictional outbreak, and asked if any of us were interested in assisting with this investigation under the supervision of Associate Professor Mahomed Patel. I, along with Fiona May, eagerly put our hands up to be involved.

On 9 May 2014, the Australian Health Protection Principal Committee (AHPPC) decided that a Communicable Disease Network of Australia (CDNA) working group (WG) would be convened (list of members shown in Appendix 2) to conduct the multijurisdictional outbreak investigation (MJOI). The CDNA-WG included representatives from all State and Territory Health Departments, and the office of Health Protection and the TGA of the Australian Government Department of Health, with QLD DoH as the secretariat. An epidemiological investigation team comprising two MAE scholars (myself and Fiona May) and a lecturer from the Australian National University MAE Program (Mahomed Patel) was convened as part of the WG to coordinate the epidemiological investigation and to communicate the findings back to the CDNA-WG.
Investigatory role

This outbreak investigation was a team effort. I worked on this outbreak with Fiona May under the supervision of Associate Professor Mahomed Patel. My role was varied and included the following:

- my role, in collaboration with Fiona, was to:
  - enter data from case notes documented by TGA staff into an Excel spreadsheet to create the line list and generate the epidemic curve;
  - analyse the case series data;
  - follow up missing data by contacting respective jurisdictions;
  - modify the QLD DoH *Ralstonia* case report form for this study;
  - analyse and interpret data collected for all stages of the study and generate hypotheses;
  - write up and edit multiple reports to the Communicable Disease Network Australia (CDNA) (Appendix 3), the Expert Panel, the TGA, the AHPPC and ProMED alert (Appendix 4);

- I conducted a rapid literature review in the early stages of the investigation to identify reports on past outbreaks associated with propofol and *Ralstonia* spp. and to determine the growth characteristics of *Ralstonia* spp. in propofol solution (Appendix 5);

- for the MJOI report, Fiona, Mahomed and I took the lead on separate components of the report. I was responsible for writing the introduction, summary of cases and results of applying the Bradford-Hill framework to our findings;

- I co-facilitated the Delphi rounds;

- I attended all CDNA-WG meetings with the working group.
### Lessons learnt

<table>
<thead>
<tr>
<th>Lesson learnt</th>
<th>What I would do next time</th>
</tr>
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<tbody>
<tr>
<td>Well defined governance of an outbreak investigation is very important. There are no specific guidelines or resources for responding to a multijurisdictional outbreak of a non-notifiable disease in Australia.</td>
<td>Define CDNA-WG members’ responsibilities and availabilities at the beginning of the investigation.</td>
</tr>
<tr>
<td>Recommendations posted on one website insufficient to reach all health professionals involved with administering intravenous medications.</td>
<td>In addition to posting recommendations on the TGA website, post recommendations on health department’s websites, as well as ask members of the CDNA and the AHPPC to share the recommendations with their networks.</td>
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</table>
| High response rates are difficult to achieve even for questionnaires distributed to public health professionals. | 1. Request jurisdictions to nominate one person to be responsible for completing questionnaires, such as other MAE scholars placed in the relevant jurisdictions.  
   2. Prioritise survey questions to try to make *Ralstonia* case report form shorter.  
   3. Modify questions for the Delphi approach that allow for more yes/no answers to try to focus respondent’s answers. |
| Obtaining WGS results can take a long time if a request for results to be expedited is not made. | Request the tests to be expedited and use laboratories within the Public Health Laboratory Network such as the Public Health Microbiology, Communicable Disease, Forensic and Scientific Services, Queensland. |
| Difficult to exclude other possible sources of contamination without environmental investigations. | 1. Arrange to inspect the manufacturing facility and take swabs of the areas where propofol is manufactured to first of all see if *Ralstonia* is present and secondly, to see the genetic similarity between the isolates obtained from the factory and the patient isolates here.  
   2. Inspect hospitals/take swabs of areas where patients were administered propofol to identify other possible sources of *Ralstonia* spp.  
   3. Inspect laboratories/take swabs where propofol was tested to see if laboratories are contaminated with the same strains of *Ralstonia* spp.  
   4. Ensure the use of appropriate control vials in all testing undertaken as part of the investigation. |
| Challenging to synthesise large volumes of qualitative information from the Delphi questions (Appendices 15 to 17c). | Consider using software designed to analyse qualitative data to assist with Delphi analysis. |
WGS provides a powerful tool for outbreak investigations such as this, but loses its usefulness if it takes too long to get the results. Samples were sent to UQCCR in May 2014 and results were not available until October 2014.

Request the tests to be expedited (available within a fortnight) and use laboratories within the Public Health Laboratory Network.

| Have a face to face debrief after an investigation (particularly a difficult one) to capture and document lessons learnt. | Debrief with TGA, CDNA, AHPPC and the WG. |

Public health impact
The TGA posted on their website a reminder for all health professionals in Australia on the importance of using aseptic technique when preparing and administering intravenous medication, with a particular focus on the need to swab the rubber stopper of any vial with a suitable disinfectant prior to drawing up sterile solutions.

This investigation highlighted the importance of strict aseptic techniques and the need for clearer instructions in the product information of medications, and ongoing continuing education for health professionals. This investigation also highlighted the need for guidelines on how to respond to multijurisdictional outbreaks of non-notifiable diseases in Australia as there are for notifiable diseases.

Acknowledgements
I would like to thank:

- associate Professor Martyn Kirk for identifying this as an opportunity for us to work on as part of our MAE;
- the TGA for giving us the opportunity to work on this investigation as part of our MAE;
- Karen Longstaff (TGA) for reviewing this chapter;
- the CDNA-WG for their input and the expert panel members for the time they contributed to taking part in the Delphi rounds;
- my placement for allowing me to work on this outbreak;
- the *Ralstonia* MAE team for being a great team to work with; and
- Mahomed Patel for his patience, supervision and guidance throughout this complex investigation.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AMS</td>
<td>Applied Microbiology Services</td>
</tr>
<tr>
<td>AHPPC</td>
<td>Australian Health Protection Principal Committee</td>
</tr>
<tr>
<td>CDNA</td>
<td>Communicable Disease Network of Australia</td>
</tr>
<tr>
<td>DoH</td>
<td>Department of Health</td>
</tr>
<tr>
<td>GCUH</td>
<td>Gold Coast University Hospital</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive care unit</td>
</tr>
<tr>
<td>MAE</td>
<td>Master of Applied Epidemiology</td>
</tr>
<tr>
<td>MALDI-TOF</td>
<td>Matrix-assisted laser desorption/ionization</td>
</tr>
<tr>
<td>MJOI</td>
<td>Multijurisdictional outbreak investigation</td>
</tr>
<tr>
<td>PHLN</td>
<td>Public Health Laboratory Network</td>
</tr>
<tr>
<td>QLD</td>
<td>Queensland</td>
</tr>
<tr>
<td>RBWH</td>
<td>Royal Brisbane Women’s Hospital</td>
</tr>
<tr>
<td>SA</td>
<td>South Australia</td>
</tr>
<tr>
<td>TGA</td>
<td>Therapeutic Goods Administration</td>
</tr>
<tr>
<td>TPCH</td>
<td>The Prince Charles Hospital</td>
</tr>
<tr>
<td>UQCCR</td>
<td>University of Queensland Centre for Clinical Research</td>
</tr>
<tr>
<td>VIC</td>
<td>Victoria</td>
</tr>
<tr>
<td>WG</td>
<td>Working group</td>
</tr>
<tr>
<td>WGS</td>
<td>Whole genome sequencing</td>
</tr>
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</table>
Abstract

Background
On 1 May 2014, the Therapeutic Goods Administration (TGA) was notified of three cases of *Ralstonia* bacteraemia from two different hospitals in South Australia (SA). Initial investigations carried out by the SA Department of Health (DoH) revealed that one or two batches of Provive propofol were the only common exposure between the three cases. On 2 May 2014, the TGA quarantined the two implicated batches, released a statement (Appendix 1) advising health professionals to avoid the use of Provive propofol and as another product, Sandoz 1% that was manufactured at the same site as the Provive. In response to the TGA’s announcement, between the 5 and 8 of May 2014, a further four cases of *Ralstonia* bacteraemia were reported by the Queensland (QLD) DoH and one from the Victorian (VIC) DoH. All cases had received Provive propofol 1% solution. On 9 May 2014, The TGA initiated a multijurisdictional epidemiological investigation.

Objectives
1. To assess the possibility of a causal association between the administration of propofol and *Ralstonia* bacteraemia that occurred since 1 January 2014, and to identify possible sources of contamination.
2. To explore other possible sources of exposure of the cases to *Ralstonia* spp.

Methods
The TGA requested via OzBugs (Australasian Society for Infectious Diseases) and internationally via ProMED (Appendix 4) that any cases of *Ralstonia* bacteraemia occurring since 1 January 2014 be reported to the TGA. A case was defined as anyone reported with a blood culture positive for *Ralstonia* spp. since 1 January 2014 based on the recommendation of the Australian Health Protection Principal Committee (AHPPC) teleconference held on 9 May 2014.

Initially, the TGA commenced its own investigations which involved identifying implicated batches of propofol and placing them in quarantine, collating and reviewing reports of possible cases reported by the States and Territories and undertaking microbiological investigations of the commercial propofol samples and containers. We entered relevant data collected by the TGA into excel to create a line list (Appendix 6) and followed up any missing data with the jurisdictions. To obtain further information on other possible sources of *Ralstonia* spp. we adapted a case report form originally
developed by QLD DoH (Appendix 7) to collect demographic and clinical data, as well as details relating to the administration of the propofol and the clinical unit. A copy of the original case report form and our adapted version are shown in appendices 7 and 8, respectively.

The TGA, SA Pathology, Applied Microbiology Services (ams) Laboratories, Claris Lifesciences (India) (manufacturer of the suspected propofol 1% emulsion products) and ESR (on behalf of Medsafe New Zealand) tested the propofol solution for sterility, microbial contamination and bacterial endotoxin. The TGA, SA Pathology and ams Laboratories also tested the flip-off lids and external surface of the rubber stoppers of the propofol vials for microbial contamination. All patient isolates were identified by culture, Vitek or matrix-assisted laser desorption/ionization (MALDI-TOF) and 16S sequencing at the respective hospital laboratories. To determine similarity between the species, all patient isolates were sent to the University of Queensland Centre for Clinical Research (UQCCR) for DiversiLab® analysis and whole genome sequencing (WGS). We applied the Bradford Hill framework and the Delphi method to assess the likelihood of a causal association between the administration of propofol and \textit{Ralstonia} bacteraemia.

\textbf{Results} \\
Eight cases were reported from 1 April and 4 May 2014 and an additional three cases between 26 June and 11 of September 2014. Because our epidemiological investigation was completed before the notification of the last three cases; this investigation report is focused on the initial eight cases.

Four cases were from QLD, three from SA, and one from VIC. Two QLD cases were from the Gold Coast University Hospital (GCUH), one from Royal Brisbane Women’s Hospital (RBWH) and one from The Prince Charles Hospital (TPCH). The VIC case was from a private hospital in Warrnambool. While two of the SA cases were from Royal Adelaide Hospital (RAH), the third was from a private hospital.

The ages of the cases ranged from 28 – 64 years. All of the initial eight cases received propofol between 1 and 27 April before the onset of their bacteraemia. The exact batches administered were confirmed only for the case from TPCH, while batch details used in the other cases were either not known or narrowed down to two or four possible batches. The time interval between propofol administration and the onset of symptoms of bacteraemia ranged from 1 hour to 23 days.
Six patient isolates were identified as *Ralstonia mannitolilytica* (three from QLD, two from SA, one from VIC), one as *R. picketti* (SA) and one as *R. insidiosa* (QLD). Of the *R. mannitolilytica* isolates, the isolates from SA patients (from SA private and RAH SA) were indistinguishable from each other as were three QLD isolates (two from GCUH and one from RBWH). However the *R. mannitolilytica* isolates from the three states (QLD, SA and VIC) were all different to each other.

No evidence of bacterial contamination of the propofol solution was found, however, 18% of the flip off caps and external surface of the rubber stoppers were positive for bacterial contamination. The species isolated included *Bacillus* spp., Gram positive cocci, coagulase negative staphylococci and *R. mannitolilytica*. The latter was isolated from one pooled sample of lids and rubber stoppers from five vials from one implicated batch by SA Pathology. This species of *R. mannitolilytica* was 97% identical to the *R. mannitolilytica* species isolated from the two SA cases.

Because of the uncertainty of a causal association, we used the Bradford Hill framework to assess the likelihood of a causal association between the administration of propofol and *Ralstonia* bacteraemia. Using this framework, we concluded that the contaminated vial cap/rubber stopper could have been the common source for the two *R. mannitolilytica* cases from SA, however, it was difficult to assign the cap/rubber stopper of the propofol vial as the common source for the five genetically different species of *Ralstonia* occurring in three different states with none of the species being common across the three states.

The expert panel that took part in the Delphi method reached consensus on three issues:

1. There was no evidence to suggest that the propofol solution was contaminated with *Ralstonia* spp.;
2. The external surface of the injection vials, including the outer surface of the rubber stopper and the inner surface of injection vial lid, should not be expected to be sterile;
3. The source of the two cases with *Ralstonia* bacteraemia at the GCUH was contaminated bottled water.
The panel could not reach consensus on the source of *Ralstonia* for the RBWH, SA, TPCH and VIC cases.

**Conclusion**

Based on the evidence available at the time, there was no evidence to suggest an epidemiological link to implicate propofol as the common source of *Ralstonia* spp. for all eight cases. The propofol solution passed all sterility, bacterial endotoxin and microbial contamination tests but 18% of the flip-off caps and external surfaces of the rubber stoppers were contaminated with a variety of bacterial species including *R. mannitolilytica*. Investigations conducted by GCUH revealed that bottled water contaminated with *R. mannitolilytica* was the source of *Ralstonia* in the two GCUH cases but the source of *Ralstonia* in the other cases could not be determined. Even though a common source of infection could not be determined, this investigation highlighted the need for proper aseptic techniques when administering intravenous injections to patients.

*On 21 October 2014 (after our investigations had been completed) the WGS results became available. They revealed that the *R. mannitolilytica* VIC isolate was indistinguishable from the two *R. mannitolilytica* isolates from SA and from the *R. mannitolilytica* isolated from the outer surface of the propofol vial. These *R. mannitolilytica* isolates from SA, VIC and the outer surface of the propofol vial were genetically different from the three *R. mannitolilytica* isolates from QLD.*

This new evidence provides stronger evidence to implicate the outer surface of the propofol vial as a possible common source for the two *R. mannitolilytica* SA cases and the VIC case, and therefore further highlights the need for strict aseptic technique when administering intravenous medications. However, the previously mentioned limitations which prevented us from being able to implicate the outer surface of the propofol vial with certainty still remain.
Introduction

**Ralstonia**

*Ralstonia* spp. are a large group of gram negative, aerobic bacteria that are emerging as opportunistic pathogens (1). They have had various name changes over the years as genetic identification of bacteria has improved. In the past they have been known as *Pseudomonas* (2, 3) and *Burkholderia* (3, 4). They are found in soil and many different types of water sources (1) including municipal drinking supplies (5), bottled mineral water (6), hospital water supplies (7), laboratory-based high purity water systems (8), industrial ultra-pure/high-purity water (9-11) and space shuttle water systems (12). They are hardy organisms capable of surviving a wide range of disinfectants and antimicrobials (13). *R. Picketii, R. insidiosa* and *R. mannitolyltica* have been isolated from a variety of clinical specimens including blood, urine and cerebrospinal fluid (14), and lung sputum of cystic fibrosis patients (15, 16).

Nosocomial outbreaks and multijurisdictional outbreaks caused by *Ralstonia* have been reported previously and have been largely attributed to contaminated medical devices (17-22) and solutions (7, 23-27, 28, 29, 30), both contaminated at the hospital or at the time of manufacture or from an unknown source (31, 32).

**Propofol**

Propofol is a general anaesthetic widely used in Australia in adults and children aged three years and over (33). The TGA estimates that approximately 4,806 vials of Provive propofol 1% solution are used across Australia each day (33).

Propofol is a lipid-based, emulsive anaesthetic (33). It is an excellent growth medium for a wide variety of microorganisms (gram positive and negative bacteria, and yeasts) (34-50). The lipid based emulsion in propofol provides a rich environment for the microorganisms to thrive (51-56). No studies have specifically investigated growth of *Ralstonia* in propofol solution, however, biochemically similar species of bacteria such as *B. cepacia* and *Pseudomonas* do proliferate rapidly in propofol solution (43, 44, 51, 53, 57). Microbial contamination of propofol results in rapid multiplication after an initial latent period ranging from around two to 24 hours (35, 39, 43, 44, 46, 47, 57, 58).

A Ralstonia related outbreak has not previously been reported in the peer-reviewed literature from contaminated propofol solution.
**Notification of outbreak**

On 1 May 2014, the SA DoH notified the TGA of three patients in two different hospitals in SA who developed *Ralstonia* bacteraemia. Initial investigations carried out by SA DoH revealed Provive propofol as the only common exposure between the three cases. Either one or two batches of Provive propofol were initially implicated (A030906 and/or A030907). On the following day (2 May) the TGA quarantined the two implicated batches and released a statement advising health professionals to avoid the use of Provive as well as the Sandoz 1% propofol products because both products are manufactured by the same company [Claris Life Sciences at the same manufacturing site in India] (Appendix 1). Following the TGA’s announcement, an additional four patients with *Ralstonia* bacteraemia were reported from QLD DoH and one from VIC DoH, all of whom had received propofol. The TGA initiated a multijurisdictional epidemiological investigation to gather data for assessing a possible causal association between propofol administration and *Ralstonia* bacteraemia, and to identify possible sources of contamination.

**Study objectives**

1. to assess the possibility of a causal association between the administration of propofol and *Ralstonia* bacteraemia that occurred since 1 January 2014, and to identify possible sources of contamination;

2. to explore other possible sources of exposure of the cases to *Ralstonia* spp.

**Methods**

This section describes the methods we used to answer the study objectives. In brief, the TGA started the investigation with epidemiological and laboratory investigations, and a review of the manufacturer’s documentation of the environmental investigations conducted by the manufacturer. In addition to assisting with the epidemiological investigations, we entered and analysed the data originally collected by the TGA and assessed whether the propofol was causally associated with the *Ralstonia* bacteraemias by applying the Bradford hill framework followed by the Delphi approach.

**Epidemiological investigation**

The TGA requested via OzBugs (Australasian Society for Infectious Diseases) and internationally via ProMED (Appendix 4) that any cases of *Ralstonia* bacteraemia occurring since 1 January 2014 be reported to the TGA. A case was defined as anyone reported with a blood culture positive for *Ralstonia* spp. since 1 January 2014 based on the recommendation of the AHPCC teleconference held on 9 May 2014. This date was
selected based on information we received from the Australian distributor of Provive propofol, AFT Pharmaceuticals who advised that the implicated batches were not distributed in Australia until 2014.

Initially, the TGA commenced their own investigations which involved identifying implicated batches of propofol and placing them in quarantine, collating and reviewing reports of possible cases reported by the States and Territories and undertaking microbiological investigations. We entered relevant data collected by the TGA into Excel to create a line list (Appendix 6) and followed up any missing data with the jurisdictions.

To obtain further information on other possible sources of Ralstonia spp. we adapted the case report form developed originally by QLD DoH for our study; it included demographic and clinical data, as well as details relating to the administration of the propofol and the clinical unit. Copies of the original case report form and our adapted version are shown in appendices 7 and 8, respectively.

To establish whether the number of Ralstonia cases was an increase from baseline in Australia, Dr Gary Lum requested data on previous isolations of Ralstonia bacteraemia from all laboratories affiliated with the Public Health Laboratory Network (PHLN).

**Laboratory investigations**

**Testing patient isolates**
Blood culture isolates were initially identified as Ralstonia species by culture and further analysed by Vitek (automated microbial identification system) or MALDI-TOF and 16S sequencing at the respective hospital laboratories.

To determine how similar the strains were, all isolates were sent to the University of Queensland Centre for Clinical Research (UQCCR) for DiversiLab® analysis (a commercial method that gives a percentage of clonality i.e. how similar the strains are) and WGS (a method that reveals an organism’s whole genome sequence) (59). WGS was conducted using an Illumina HiSeq2500 and phylogenomic software in the Beatson laboratory at UQCCR.

**Testing propofol vials**
The TGA, SA Pathology, Applied Microbiology Services (ams) Laboratories, Claris Lifesciences (India) and ESR (New Zealand) tested the propofol solution for sterility, microbial contamination and bacterial endotoxin. The TGA, SA Pathology and ams
Laboratories also tested the flip-off lids and external surfaces of the rubber stoppers of the propofol vials for microbial contamination (60).

**Environmental investigations**
Notifying clinicians were requested to provide results from any environmental swabs or other tests conducted at the facility/units where the cases were administered the propofol.

The TGA reviewed Claris Lifesciences Ltd.’s documents to review processes for manufacturing propofol 1% emulsion for injection products.

**Assessing causation**
We initially applied the Bradford Hill framework to assess the causal association between the administration of propofol and *Ralstonia* bacteraemia followed by the Delphi method.

**The Delphi method**
The Delphi method was used to explore and collect independent judgments from an expert panel on the likelihood that the initial eight cases of *Ralstonia* bacteraemia were causally associated with propofol. The CDNA-WG nominated a panel of experts which consisted of three infectious disease physicians (two of whom were professors of infectious diseases), two clinical microbiologists, an epidemiologist and a public health physician. The list of members is shown in Appendix 9. The Delphi method is a communication technique used to achieve consensus within an expert panel through a series of questions and anonymous discussions (61). In total three rounds of the Delphi method were conducted over a period of two months. The purpose of the first round was to obtain comments and suggestions on the appropriateness of a set of issues/questions to be explored by the panel. The purpose of the second round was for panel members to respond to the questions agreed upon in the preceding round and the purpose of the third round was for members to comment on each other’s responses and the facilitator’s conclusions and to reconsider their initial responses (from the second round) and to assess the plausibility of six hypotheses posed by the facilitators. At the end of each round, we (the facilitators) synthesised and summarised each of the responses which we then re-distributed for discussion.
Results
This section describes the results of our investigations. I first describe the epidemiological findings, followed by the laboratory and environmental findings, and I conclude this section by describing the results of the Delphi method.

**Epidemiological findings**
In total, eleven cases of *Ralstonia* bacteraemia were reported between 1 April and 11 September 2014 (Figure 1). Eight cases were reported from 1 April and 4 May 2014 and an additional three cases were reported between 26 June and 11 of September. The initial investigation was conducted in mid - June and completed before the notification of the last three cases; therefore this investigation report is focused on the initial eight cases.

*The initial eight cases*
Eight cases were reported since 1 January 2014 (Figure 1). Four cases were from QLD, three from SA, and one from VIC (Figure 2). Two QLD cases were from the Gold Coast University Hospital (GCUH), one from Royal Brisbane Women’s Hospital (RBWH) and one from The Prince Charles Hospital (TPCH). The VIC case was from a private hospital in Warrnambool. Two of the SA cases were from Royal Adelaide Hospital (RAH) and the third from a private hospital. The ages of the cases ranged from 28 – 64 years.

All eight cases received propofol between 1 and 27 April (< 1 day to 23 days prior to onset) before onset of bacteraemia (Figure 1). Six cases received Provive, one received the Sandoz product only and one received both Provive and Sandoz propofol (Appendix 6). The exact batches administered were confirmed only for the case from TPCH (Sandoz Propofol Batch number A031110 and A030504), while batch details used in the other cases were either not known or narrowed down to two or four possible batches.

Date of onset of bacteraemia ranged from 1 April to 4 May. The time interval between propofol administration and onset of symptoms of bacteraemia ranged from 1 hour to 23 days. The shortest intervals of one hour and 5 hours were in two patients who had had endoscopies in SA and VIC respectively, while the longer intervals of 23 days and either 16 or 23 days were in patients at the GCUH, in known intravenous drug users, one of whom also had tricuspid endocarditis. The one patient with an interval of 17 days had severe influenza pneumonia at the TPCH. The intervals for the remaining three
patients ranged from four to six days (the epidemiological line list is shown in Appendix 6).

**Cases identified after the initial investigation**

Three additional *Ralstonia* bacteraemic cases were reported after the initial investigation. One case was reported from RBWH on 26 June 2014, and had had not received any propofol. He was a 59 years old and was admitted to TCH hospital on 29 May 2014 and later transferred to RBWH. He was receiving chemotherapy for acute myeloid leukaemia.

Another case was reported on 3 September 2014 from VIC and another on 11 September 2014 from SA. Both of these cases had received propofol however, no further demographic or clinical information is known about these additional two cases.

**Figure 1:** Epidemic curve showing the eight cases with *Ralstonia* bacteraemia since 1 January 2014 by date of detection of infection and date of propofol administration.

Colour coding shows genetic similarity of clinical isolates of the eight initial cases based on DiversiLab® results. P = date when propofol was administered. PI = dates of propofol infusion. For “VIC” and “SA private”, date of propofol administered was same as detection of bacteraemia. QLD = Queensland, SA = South Australia, VIC = private hospital in Warrnambool, RAH = Royal Adelaide Hospital, GCUH = Gold Coast University Hospital, RBWH = Royal Brisbane & Women’s Hospital, TPCH = The Prince Charles Hospital, ENDO = gastro-intestinal endoscopy unit, OT = operating theatre, ICU = intensive care unit.
Non-bacteraemic cases
GCUH also reported eight patients with non-bacteraemic *Ralstonia* infections. Six of these patients had *Ralstonia* isolated from their sputum or trachea, one had *Ralstonia* isolated from their urine and one had *Ralstonia* isolated from an unknown source. The results of 16S rRNA, DiversiLab® analysis, specimen types, source of isolates and the history of previous administration of propofol are shown in Appendix 10.

Was this a real increase in cases?
Reports provided by laboratories affiliated with the PHLN revealed that the number of isolations of *Ralstonia* from blood samples since 2012 ranged between zero to three per State/Territory annually, and an estimated average of four cases nationally (Appendix 11).

Laboratory investigations

Testing of patient isolates for the eight initial cases

16S rRNA
The 16S rRNA sequencing results showed that of the eight initial bacteraemic cases, six patient isolates were identified as *R. mannitolilytica* (three from QLD, two from SA, one from VIC), one as *R. picketti* (SA) and one as *R. insidiosa* (QLD) (Figures 2 and 3).

DiversiLab®
DiversiLab® analysis determined that we had five genetically different strains of *Ralstonia* amongst the three different species (Appendix 10). Of the *R. mannitolilytica* isolates, the two SA isolates (from SA private and RAH SA) were indistinguishable from each other as were the three QLD isolates (two from GCUH and one from RBWH). However the *R. mannitolilytica* isolates between the three states (QLD, SA and VIC) were all different to each other (Table 1).

WGS
The WGS results revealed that the *R. mannitolilytica* VIC isolate was indistinguishable from the two *R. mannitolilytica* isolates from SA and from the *R. mannitolilytica* isolated from the outer surface of the propofol vial. The three QLD isolates *R. mannitolilytica* were also indistinguishable from each other, but were easily distinguishable from the SA and VIC isolates (Figure 3 and Table 1). *This information became available to us after the initial investigation and report write up had been completed.*
Figure 2: Map of Australia showing the eight cases of *Ralstonia* bacteraemia in South Australia, Queensland and Victoria since 1 January 2014 by location

Table 1: Summary of laboratory results for the initial eight cases in South Australia, Queensland and Victoria, 1 April to 26 June 2014

<table>
<thead>
<tr>
<th>State</th>
<th>Hospital</th>
<th>Specimen</th>
<th>Bottled water</th>
<th>Propofol</th>
<th>16S rRNA</th>
<th>DiversiLab</th>
<th>WGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>RAH</td>
<td>Blood</td>
<td>No</td>
<td>Yes</td>
<td><em>R. picketti</em></td>
<td>Singleton 2</td>
<td>Clade 2</td>
</tr>
<tr>
<td>SA</td>
<td>RAH</td>
<td>Blood</td>
<td>No</td>
<td>Yes</td>
<td><em>R. mannitolilicta</em></td>
<td>Cluster 3</td>
<td>Clade 3b</td>
</tr>
<tr>
<td>SA</td>
<td>Private</td>
<td>Blood</td>
<td>No</td>
<td>Yes</td>
<td><em>R. mannitolilicta</em></td>
<td>Cluster 3</td>
<td>Clade 3b</td>
</tr>
<tr>
<td>QLD</td>
<td>GCUH</td>
<td>Blood</td>
<td>Yes</td>
<td>Yes</td>
<td><em>R. mannitolilicta</em></td>
<td>Cluster 1</td>
<td>Clade 3a</td>
</tr>
<tr>
<td>QLD</td>
<td>GCUH</td>
<td>Blood</td>
<td>Yes</td>
<td>Yes</td>
<td><em>R. mannitolilicta</em></td>
<td>Cluster 1</td>
<td>Clade 3a</td>
</tr>
<tr>
<td>QLD</td>
<td>RBWH</td>
<td>Blood</td>
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<td>Yes</td>
<td><em>R. mannitolilicta</em></td>
<td>Cluster 2</td>
<td>Clade 3a</td>
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<tr>
<td>QLD</td>
<td>TPCH</td>
<td>Blood</td>
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<td>Yes</td>
<td><em>R. insidiosa</em></td>
<td>Singleton 6</td>
<td>Clade 1</td>
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<tr>
<td>VIC</td>
<td>Private</td>
<td>Blood</td>
<td>No</td>
<td>Yes</td>
<td><em>R. mannitolilicta</em></td>
<td>Singleton 3</td>
<td>Clade 3b</td>
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Figure 3: Cases of *Ralstonia* bacteraemia by state, hospital and possible source of exposure, 1 April to 26 June 2014
Testing of patient isolates for cases identified after the initial investigation

The isolate from the ninth case reported from RBWH on 26 June who had not received propofol was indistinguishable (on DiversiLab®) to the isolates from the first case at the RBWH and the isolates from the two cases at the GCUH. At this stage there is no genetic (WGS or DiversiLab®) information on the isolates from the last two cases.

Non-bacteraemic cases

The *Ralstonia* isolates from the non-bacteraemic cases were *R. mannitolilytica*, indistinguishable from the *R. mannitolilytica* isolated from GCUH and RBWH *Ralstonia* bacteraemia cases (Appendix 10).

Results from GCUH Investigation

The GCUH conducted their own outbreak investigation into their two cases with *Ralstonia* bacteraemia and eight cases with *Ralstonia* isolates from other samples. Their investigation concluded that the source of *Ralstonia* at the GCUH was bottled water contaminated with *R. mannitolilytica*.

Testing of propofol vials

The detailed results of the propofol testing are shown in Appendix 12. But overall, from 25 batches, the propofol solution from 1,683 vials were tested for sterility, 97 were tested for the presence of bacterial endotoxin and 91 vials were tested for microbial contamination by the TGA, SA Pathology, Applied Microbiology Services (ams) Laboratories, Claris Lifesciences (India) and ESR (New Zealand). All samples passed the criteria for the tests for sterility and bacterial endotoxins, and for microbial contamination testing of vial contents.

A total of 524 flip-off caps and external surfaces of rubber stoppers from 15 product batches were also tested by SA Pathology, ams Laboratories and the TGA for microbial contamination. Eighteen percent (*n* = 88) were positive for bacteria. TGA isolated *Bacillus* spp., and Gram positive cocci. SA Pathology isolated *R. mannitolilytica*, *Bacillus* spp. and Coagulase negative staphylococci. *R. mannitolilytica* was isolated from one pooled sample of flip-off lids and swabs of the external surface of rubber stoppers from five vials from one of the implicated batches (A030907). The *R. mannitolilytica*, isolated from the top surface of the vial was identified by DiversiLab® analysis as being closely related (97% similarity) to the *R. mannitolilytica* isolated from the two SA cases. SA
Pathology did not use controls during testing. This batch was sent to the TGA for testing but the TGA was not able to replicate this result.

**Environmental investigations**
The notifying clinicians did not provide any data on swab/specimens or samples of medical products from other possible sources for any of the cases. Details of the type of environmental samples collected and tested, if any, were not provided by any of the hospitals. The TGA’s investigations of the documentation of the manufacturer’s processes for manufacturing propofol 1% emulsion for injection products did not find any deviations from approved processes.

**Next step, analytical study?**
Alternative scenarios were simulated to assess whether a historical cohort study or case control study could yield meaningful results to assess the causal association between the administration of propofol and *Ralstonia* bacteraemia (appendices 13a and 13b). We generated scenarios where the eight cases were compared with controls (case control study) and with a cohort of patients (case cohort) who had been in the same facility as the cases during the period when the cases had received propofol, but who did not have *Ralstonia* bacteraemia. We made the assumption that when each case was in a facility, there were at least ten other patients in the same facility who had the chance of receiving propofol and that the proportion of control subjects who had received propofol ranged between 15% and 90%. We calculated the Odds Ratios (OR) for each of these possible scenarios as shown in appendices 13a and 13b.

The shaded rows in both tables (appendices 13a and 13b) show the percentage of controls who received propofol at the point at which the OR becomes statistically significant. Based on the results of these simulations we decided that neither a case control nor a case cohort study would yield a statistically significant OR and/or relative risk because all the control subjects in an endoscopy/colonoscopy unit and around 50% - 60% of subjects in an Intensive Care Unit or theatre are likely to have received propofol. These scenarios revealed that our sample size (n = 8) was too small to be able to conduct an analytical study that would produce results of statistical significance.
Assessing causation

Bradford Hill Framework
We applied the Bradford Hill framework to assess the causal association between the administration of propofol and *Ralstonia* bacteraemia (Appendix 14). From this analysis we concluded that the contaminated flip-off cap/rubber stopper could have been the common source for the two *R. mannitolilytica* cases from SA if we can accept that the *Ralstonia* isolated from the vial cap rubber stopper was a valid result and not a contaminant (not possible to know without using controls) and if the WGS further confirms that these three isolates are genetically identical. *These findings were further supported by the WGS results.*

However, it was difficult to assign the flip-off cap/rubber stopper of the propofol vial as the common source for the five genetically different species of *Ralstonia* occurring in three different states with no overlap in species between states (Figure 2).

Using this framework, we were not able to confirm a causal association between the flip-off/rubber stopper and all eight cases. We therefore decided to use the Delphi method with a group of experts to help formulate and explore additional hypotheses, and in this way, to offer alternative explanations for this unusual increase in *Ralstonia* bacteraemias.

Delphi results

Delphi round 1 results
In Round 1 the expert Panel Members offered comments and suggestions on the issues and the questions for consideration. The panel agreed on the following eight questions/issues to be discussed:
Question 1: What incubation period could be considered consistent with a causal association between propofol administration and bacteraemia?

Question 2: If we assumed that propofol administration was causally associated with bacteraemia, can we conclude that pre-existing contamination of the propofol solution was unlikely and that the vial cap and/or rubber stoppers were more likely to have been the source of the *Ralstonia*?

Question 3: How confidently can we exclude other possible sources of exposure (apart from propofol administration) to *Ralstonia* in some or all the cases?

Question 4: How likely is it that a patient with *Ralstonia* bacteraemia but without signs of a pulmonary infection may have transmitted *Ralstonia* to another patient as an explanation of why the same strain of *Ralstonia* was isolated from the sputum or tracheal aspirate of a patient who never received propofol?

Question 5a: How should we interpret the finding of the *Ralstonia* isolate from the vial cap, noting the caveat from SA Pathology?

Question 5b: How should we interpret the TGA result of contamination of the internal surface of flip-off seal and rubber stopper with other bacteria?

Question 5c: How do these interpretations influence your judgement of the hypothesis that propofol administration is causally associated with *Ralstonia* bacteraemia?

Question 6: Can we confidently implicate or exclude propofol administration as the cause of *Ralstonia* bacteraemia in some or all the cases? Where and when could the propofol/vial have been contaminated?

Question 7: Noting the genetic similarity between the *R. mannitolilytica* isolate from the propofol vial cap and the clinical isolates from the two cases in different SA hospitals (RAH and SA Private), and the distinctive *R. picketti* isolate from the second patient in the same neurosurgical unit of the RAH, can we conclude that *Ralstonia* bacteraemia in all three cases was causally associated with the administration of propofol, and that the propofol/vial did not become contaminated in the respective clinical unit?

Question 8: How confident can we be that the cases reported in QLD and/or VIC with diverse genetic strains were also causally associated with the administration of propofol because all of them had received propofol?

Question 9: Based on the DiversiLab® results and on the uncertainty of the batch number of propofol vials used in SA, VIC and QLD, what plausible hypotheses could we formulate on the likely site/s of contamination? More specifically, how likely is it that the propofol/vial may have been contaminated (a) at some stage before delivery to the clinical unit and (b) after arrival in the clinical unit?

Question 10: What is the likelihood the propofol/vial was contaminated at the site of manufacture at Claris Life Sciences (India)?
**Delphi round 2 results**

In Round 2, six of the seven Panel Members provided their independent responses to a total of twelve questions agreed upon in the first round. Individual responses are shown in Appendix 15.

**Delphi round 3 results**

Panel members were given a summary of responses from Round 2 together with the facilitators’ conclusions and selected literature references. They were invited to comment on these and offer their opinions on six hypotheses in the different clinical settings from which cases had been reported with *Ralstonia* bacteraemia. Five of the seven Panel Members commented on the Round 2 responses to the twelve questions and the facilitators’ conclusions (Appendices 16, 17a, 17b, 17c).

**Summary of Delphi results**

The expert panel reached consensus on three issues:

1. There is no evidence to suggest that the propofol was contaminated with *Ralstonia* spp.
2. The external surface of the injection vials, including the outer surface of the rubber stopper and the inner surface of injection vial lid, should not be expected to be sterile
3. The source of the two cases with *Ralstonia* bacteraemia at the GCUH was contaminated bottled water

The panel could not reach consensus on the source of *Ralstonia* for the RBWH, SA, TPCH and VIC cases.


Discussion

This chapter describes an unusual increase of cases with *Ralstonia* bacteraemia that occurred from 1 April to 26 June 2014. A common source of infection could not be confirmed for all cases due to the availability of a small sample size of cases (n=8) and insufficient laboratory-based evidence. Bottled water contaminated with *R. mannitolilytica* was the source of *Ralstonia* for the two GCUH cases and possibly the RBWH cases; however an epidemiological link between the cases in these two hospitals could not be established. The source of *Ralstonia* in the SA, TPCH and VIC cases could not be established and no information is known about the most recent VIC or SA cases and therefore cannot be discussed.

There was no evidence to suggest that the propofol solution was contaminated with *Ralstonia* spp. However, a small proportion of the outer surface of the rubber stoppers and the inner surface of the flip-off lids from the propofol vials were found to be contaminated with a range of bacterial species including a strain of *R. mannitolilytica* that was indistinguishable from the *R. mannitolilytica* cases in SA; however it was not possible to establish causation and exclude other confounding factors (such as exposures to other intravenous substances or acupuncture needles).

Prior to notification of the ninth case, all cases had received propofol prior to the onset of bacteraemia which led us to the hypothesis that *Ralstonia* bacteraemia was probably associated with the administration of propofol. Usually the next step in an outbreak investigation after the hypothesis generating step is to test the formulated hypothesis using an analytical study. However, our small sample size (n = 8) prevented us from being able to conduct an analytical study that would yield statistically significant results. Therefore instead of an analytical study to test the hypothesis, we applied the Bradford Hill framework to determine the possibility of a causal association. Through this analysis we concluded that the contaminated vial cap and rubber stopper could have been the common source for the two cases in different hospitals in SA if the SA Pathology results were valid. However, we were still not able to explain how the vial cap and rubber stopper could be the common source for all the cases in the three states, given that the *Ralstonia* isolates belonged to four different genotypes of *Ralstonia* (excluding the GCUH and RBWH isolates), and that not one strain of *Ralstonia* occurred in more than
one state. So to try to find an explanation for this unusual increase in cases of reported Ralstonia bacteraemias we used the Delphi method.

In line with the laboratory evidence, the Delphi panel concluded that the propofol solution was not contaminated and was therefore not the source of the Ralstonia. However, the panel was not able to reach consensus on whether the contamination of the external surface of the rubber stopper of the propofol vial was the common cause of the five cases with bacteraemia (excluding RBWH and GCUH cases) due to insufficient evidence.

It was not possible to completely exclude the propofol vial because the strain of R. mannitolilytica that was isolated from the pooled sample of rubber stopper external surfaces and flip off caps from one implicated batch in SA was identical to the R. mannitolilytica strain isolated from the two SA cases. However, this evidence (which is the strongest evidence to link the propofol with the Ralstonia bacteraemia) came with caveats reported by SA Pathology: ‘The technician attempted to use sterile technique but the removal of the vial lids was difficult. Contamination may have been introduced during sampling as evidenced by the mixture of cutaneous flora [coagulase negative staphylococci] in the sub-cultures. With that caveat, an isolate of R. mannitolilytica has been obtained from an implicated box of propofol (A030907). Ralstonia spp. are rarely isolated in our laboratory’. Further to this, control vials were not used during testing in the laboratory, so we could not be certain whether this strain of Ralstonia (which is an environmental organism and a common contaminant of laboratories) was from the vial and not from the laboratory itself. Furthermore, these results could not be replicated by the TGA. There is also a lack of information on the genetic variability of Ralstonia isolates in SA hospitals and laboratories which prevents us from knowing the significance of finding three strains with an identical genetic pattern.

It was also difficult to be able to implicate the propofol vial with certainty for the other reasons:

1. It is estimated that approximately 4,806 vials of Provive propofol 1% emulsion are used across Australia each day. If the propofol vial had been contaminated at the point of manufacture, why were there only eight cases? And why were none of the strains found in more one state? While a polymicrobial
contamination of the propofol vial is plausible, it is highly unlikely that there
would be no overlap in strains between the states. As one of the Expert Panel
Members stated ‘We would expect closer clonal similarities between cases if pre-
existing contamination was the source’.

2. It was also difficult to implicate the propofol without being able to exclude all
other possible sources of Ralstonia. All cases were exposed to many other
possible sources of Ralstonia that are common in health care settings, but
without completed case report forms or environmental investigations, these
other sources could not be excluded.

Discussion of the WGS results provided post investigation

The WGS results became available after our investigation had been completed. The
WGS results confirmed the previous laboratory findings but also provided new evidence
that linked the earlier VIC case to the two SA cases and the outer surface of the rubber
stopper or flip-off lid of the propofol vial. In light of this evidence, it is possible that we
had two different outbreaks occurring at the same time: the QLD outbreak caused by
the contaminated bottled water and a SA and VIC outbreak caused by a pre-existing
contamination of the outer surface of the rubber stopper or flip-off lid of the propofol
vial, with two extra sporadic cases being notified as a result of heightened surveillance.

However, even in light of this new evidence, questions still remain unanswered that
prevent us from confirming this hypothesis. If there was a pre-existing contamination, it
is still difficult to envisage how this resulted in so few cases across Australia, especially
among immunocompromised patients in ICUs where propofol is used extensively (62). It
could be that there was sporadic contamination of the vials at the manufacturing site
(or somewhere else between the manufacturing site and the point of distribution to SA
and VIC) with different strains of Ralstonia, and that these cases occurred as a result of
a lack in aseptic technique in the SA and VIC hospitals. However, we cannot be certain
of this without further evidence. Even so, the manufacturer doesn’t guarantee that the
exterior surface of the vial is sterile, only a sterile solution (33).

We do not have any information on the genetic variability of Ralstonia isolates in the
environment, and particularly in the health care settings (hospitals and endoscopy
units) which prevent us from interpreting the significance of finding four strains with an
identical genetic pattern in two different states.
The role of potential confounders to explain the bacteraemia also cannot be excluded. All of the cases had multiple invasive procedures and were therefore exposed to many other possible sources of infection with *Ralstonia* that we were not able to control for. We therefore could not know with any certainty the true source of these *Ralstonia* bacteraemias.

**Limitations**

There were a number of limitations to this study - the most important one was having insufficient evidence to either implicate or exclude the propofol. Having a small sample size prevented us from conducting an analytical epidemiological study that could yield statistically significant results. We therefore had to resort to the Delphi method to reach consensus on the most plausible hypotheses. Even then, the group of experts could not reach consensus on all issues. A low response rate for the case report forms from notifying health professionals meant that important data on cases and the environments the cases were exposed to had not been collected. It was therefore not possible to assess or control for confounding factors.

**Conclusion**

We could not find evidence to confirm the administration of propofol was the common source of *Ralstonia* spp. for the five cases of *Ralstonia* bacteraemia in the three jurisdictions. Bottled water contaminated with *R. mannitolilytica* was the source of *Ralstonia* in the two GCUH cases (and possibly in the case who had not received propofol at RBWH) but the source of *Ralstonia* in the other cases could not be confirmed.

This investigation was a complex, interesting investigation. While we could not find a common source of infection, it produced some very important findings. It revealed there is confusion among clinicians and anaesthetists on the need to swab the external surface of the rubber stopper before drawing up the propofol solution. Eighteen per cent of the flip off cap/and or external surfaces of the rubber stoppers were contaminated with a variety of bacterial species. The manufacturer does not guarantee these outer surfaces to be sterile, and this is also not expected by regulatory authorities such as the TGA. Australian guidelines should therefore be revised to include clearer instructions on the need to swab the external surface of the rubber stopper with a suitable disinfectant prior to drawing up any sterile solution. In addition, there should
be ongoing continuing education made available to all health professionals across Australia responsible for administering medical solutions to patients.

*On 21 October 2014, the WGS results became available to us after the initial investigation had already been completed. The WGS analysis revealed that the *R. mannitolilytica* VIC isolate was indistinguishable from the two *R. mannitolilytica* isolates from SA and from the *R. mannitolilytica* isolated from the outer surface of the propofol vial. These *R. mannitolilytica* isolates from SA, VIC and the outer surface of the propofol vial were still genetically different from the three *R. mannitolilytica* isolates from QLD. This new evidence provides stronger evidence to implicate the outer surface of the propofol vial as a possible common source for the two *R. mannitolilytica* SA cases and the VIC case, and therefore further highlights the need for strict aseptic technique when administering intravenous medications. However, the previously mentioned limitations which prevented us from being able to implicate the outer surface of the propofol vial with certainty still remain.

**Recommendations**

At the last AHPPC meeting one member said that the outbreak is not over until the cases stop. I agree with that member’s statement. The additional three cases reported after our initial investigation suggests that this outbreak may not be over. I therefore think the next steps should be to:

1. continue active surveillance to detect any future cases and to have these cases reported back to a central group such as the CDNA-WG. This should be done until the number of reported cases of *Ralstonia* bacteraemia returns to baseline;
2. collect more information from the last two cases reported in VIC and SA similar to the information we tried to collect for the initial eight cases; and investigate any common supply routes between SA and VIC;
3. communicate to all relevant health professionals and relevant associations to notify those involved with administering propofol (and other intravenous medications) in Australia to emphasize the importance of using aseptic technique when preparing and administering intravenous medication, with a particular focus on the need to swab the rubber stopper of any vial prior to drawing up sterile solutions;
4. consider revising the Australian label and package inserts of IV medication so that they clearly state the need to swab the rubber stopper prior to drawing up the sterile solutions;

5. consider conducting a cross sectional study to investigate the proportion of external surfaces of rubber stoppers on propofol vials (or other IV vials) that are contaminated with bacteria and communicate findings back to public health professionals;

6. consider conducting a survey to investigate and further explore the misconceptions and practices among relevant public health professionals about the external surfaces of a rubber stopper being sterile.
Appendix 1: Safety advisory – potential bacterial contamination, Therapeutic Goods Administration, 2 May 2014

Health professionals, hospitals and health facilities are advised that batches of a widely used intravenous anaesthetic drug, propofol, may include some vials that have been contaminated with the bacterium Raistonia pickettii. To address this issue, APT Pharmaceuticals, in consultation with the TGA, has quarantined two batches of Propive HC7-LCT 1% (propofol 1%) emulsion for injection in 20 ml vials. This action is being taken due to potential contamination with the bacteria Raistonia pickettii.

The affected batch numbers are:
- AQ20906 (expiry date 08/15)
- AQ30907 (expiry date 08/15).

Additionally, health professionals are advised to, where possible, avoid use of all sizes and all batches of Propive and Sandooz propofol 1% products pending further investigation into this issue.
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Hospitals should seek alternatives to these brands and only use Provive and Sandoz propofol 1% products if there are no suitable alternatives and only if the benefits outweigh the risks to the patient.

Propofol 1% is used as a short-acting general anaesthetic in adults, and children aged three years or older.

There have been reports of patients having developed sepsis after Provive MCT-LCT 1% was administered to them while being treated in hospitals.

*Ralstonia picketti* are Gram-negative bacteria. It may take several days for a blood culture to become positive and may be difficult for a laboratory to identify. Possible initial identifications include *Stenotrophomonas, Burkholderia* and *Pseudomonas* species of bacteria.

**Information for consumers**

This medicine is only used in hospitals and certain health facilities.

Hospitals and health facilities have been contacted and provided further information about this issue, including details of the quarantine process.

If you have any questions or concerns about this issue, talk to your health professional.

**Reporting problems**

Consumers and health professionals are encouraged to report problems with medicines or vaccines. Your report will contribute to the TGA’s monitoring of these products.

The TGA cannot give advice about an individual’s medical condition. You are strongly encouraged to talk with a health professional if you are concerned about a possible adverse event associated with a medicine or vaccine.
Appendix 2: Members of the Communicable Disease Network of Australia Working Group, 2014

1. Dr Alexandra Greig
2. Associate Professor Ann Koehler
3. Dr Barry Combs
4. Dr Bronwen Harvey
5. Dr Claire Heney
6. Dr Gary Lum
7. Dr Heidi Carroll (CDNA-WG Coordinator)
8. John Marquess
9. Dr Mark Veitch
10. Dr Melissa McRae
11. Dr Peter Markey
12. Rosemary Steinhardt
13. Dr Sean Tobin
14. Dr Sonya Bennett
15. Karen Longstaff
16. Dr Alex Stevenson
17. Associate Professor Mohamed Patel
Appendix 3: Final Multi-jurisdictional outbreak investigation report to Communicable Disease Network of Australia, 26 May 2014

INVESTIGATION SUMMARY

MULTI-JURISDICTIONAL OUTBREAK INVESTIGATION

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<td>Report Number 1</td>
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Summary of investigation

Number of Cases 8 (one additional case in WA in Dec 2013 still to be included)
Number of controls
Potential value of formal analytic study to be discussed

Pathogen Raizstonia spp.
Suspected source Propofol manufactured by Claris Life Sciences (India)
Control Measures to date Propofol quarantined since 2 May

This report describes the investigations based on data provided to TGA to date. It is possible that there may be information jurisdictions may be aware of, and it would be helpful if this could be sent to us before the teleconference on Thursday.

A further report on the synthesis of these findings for assessing a cause-effect relationship between the use of propofol and Raizstonia bacteraemia, the potential value of an analytic epidemiological study, and options for the way forward, will be forwarded to CDNA-WG members by Wednesday 28 May.

Introduction to Investigation

South Australia (SA) notified the Therapeutic Goods Association (TGA) on the 1st May 2014 of three patients in two different hospitals who developed Raizstonia bacteraemia. Initial investigations by SA identified that propofol was the only common exposure for the cases in the two hospitals. Either one or two batches of Propova were implicated (A630906 and/or A03907) and the TGA quarantined these batches. TGA advised health professionals to avoid using Propova as well as the Sandoz 1% propofol products because both products are manufactured by the same company, Claris Life Sciences (India). Following TGA’s announcement, four patients with Raizstonia bacteraemia were reported from Queensland (QLD) and one from Victoria (VIC), all of whom had received propofol. The TGA initiated a multi-jurisdictional epidemiological investigation to gather data for assessing a possible causal association between propofol administration and Raizstonia bacteraemia, and to identify possible sources of contamination.

Case definition for reporting Raizstonia bacteraemia in this investigation

Based on the recommendation of the AHPPC t/c on 9 May, data were to be collected on

In Confidence

Please note, the information in this summary is subject to change due to the nature of outbreak investigations.
anyone reported with a blood culture positive for *Ralstonia* spp. since 1 January 2014. This start date was selected based on initial information received from the Sponsor of Propofol.

It is noted that although the implicated batches were manufactured in September 2013, they were not distributed in Australia until 2014.

**Results of investigations**

Eight cases were reported since 1 January 2014 (Figure 1). One case reported on 19 May from Western Australia occurred in December 2013, but is not included in this report as the details are still to be confirmed. Six isolates are *R. mannitolilytica*, one *R. pickettii*, and one *R. insidiosa*. Details of each case are in appendix 1.

![Epidemic curve showing cases of *Ralstonia* infection by date of onset of infection (derived from date of blood collection) and date propofol was administered for each case.](image)

**Figure 1:** Epidemic curve showing cases of *Ralstonia* infection by date of onset of infection (derived from date of blood collection) and date propofol was administered for each case. Colour coding shows genetic similarity based on DiversiLab results. P = date in April when propofol was administered, PI = dates of propofol infusion. For the cases in VIC and SA private, date of propofol was same as onset of bacteraemia.

Four cases are from Queensland (QLD), three from South Australia (SA), and one from Victoria (VIC). Two QLD cases are from the Gold Coast University Hospital (GCUH), one from Royal Brisbane Women’s Hospital (RBWH) and one from The Prince Charles Hospital (TPCH). The VIC case was from a private hospital in Warrnambool. Two of the SA cases are from Royal Adelaide Hospital (RAH) and the third from a private hospital. The ages of the cases range from 20 – 64 years.

All eight cases received propofol between 1 and 27 April before onset of bacteraemia (Figure 1). Date of onset of bacteraemia ranges from 1 April to 4 May. The time interval between propofol administration and onset of symptoms of bacteraemia ranged from 1 hour to 23 days. The shortest intervals of one hour and 5 hours were in the two patients who had endoscopies in SA and VIC respectively, while the longer intervals of 23 days and either 16 or 22 days were in patients at the GCUH, in known intravenous drug users, one of whom also had tricuspid endocarditis. The one patient with an interval of 17 days had severe influenza pneumonia at the TPCH. The intervals for the remaining three patients ranged from four to six days.

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*In Confidence –

Please note, the information in this summary is subject to change due to the nature of outbreak investigations.*
For six cases, there were multiple opportunities for acquiring the infection while in ICU or before and after surgery. The patient with metastatic cancer in SA who had an upper endoscopy and colonoscopy was injected with IV contrast medium for a CT scan 16 days before the infection. The eighth patient who had a colonoscopy for removal of polyps had acupuncture needles in situ for four days before the procedure and were removed two days thereafter.

No information is available on swab/specimens or samples of medical products from other possible sources for any of the cases. Details of the type of environmental samples collected and tested are not known for any of the hospitals. TGA has not yet been provided with any written details on the range of investigations completed to investigate all the possible common sources for the infection in the patients from the two hospitals in SA, but was told that use of the propofol was the only identifiable common source.

Six cases received **Propive**, one received the Sandoz product only and one received both **Propive** and Sandoz **propofol**. The exact batches administered are confirmed only for the case from TPCH case (Sandoz **propofol** A031110 and A030504), while batch details used in the other cases are either not known or narrowed down to two or four possible batches as summarised in Table 1.

### Table 1. Batch numbers of propofol implicated and/or tested in this investigation

<table>
<thead>
<tr>
<th>Propofol brand</th>
<th>Batch number</th>
<th>Manufacture date</th>
<th>State</th>
<th>Tested by</th>
</tr>
</thead>
<tbody>
<tr>
<td>A030906</td>
<td>09/2013</td>
<td>SA</td>
<td>TGA/Claris</td>
<td></td>
</tr>
<tr>
<td>A030907</td>
<td>09/2013</td>
<td>SA</td>
<td>TGA/Claris</td>
<td></td>
</tr>
<tr>
<td>A031195</td>
<td>Exp. date – 23 months</td>
<td>QLD</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>A031202</td>
<td>Exp. date – 23 months</td>
<td>QLD</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>A031203</td>
<td>Exp. date – 23 months</td>
<td>QLD</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>A031210</td>
<td>Exp. date – 23 months</td>
<td>QLD</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>A030021</td>
<td>01/2013</td>
<td>NA</td>
<td>TGA</td>
<td></td>
</tr>
<tr>
<td>A030146</td>
<td>02/2013</td>
<td>NA</td>
<td>TGA</td>
<td></td>
</tr>
<tr>
<td>A030293</td>
<td>04/2013</td>
<td>NA</td>
<td>TGA</td>
<td></td>
</tr>
<tr>
<td>A031266</td>
<td>12/2013</td>
<td>NA</td>
<td>TGA</td>
<td></td>
</tr>
<tr>
<td>A031267</td>
<td>12/2013</td>
<td>NA</td>
<td>TGA</td>
<td></td>
</tr>
<tr>
<td>A040081</td>
<td>01/2014</td>
<td>NA</td>
<td>TGA/AMS</td>
<td></td>
</tr>
<tr>
<td>A031266</td>
<td>12/2013</td>
<td>NA</td>
<td>AMS</td>
<td></td>
</tr>
<tr>
<td>A031267</td>
<td>12/2013</td>
<td>NA</td>
<td>AMS</td>
<td></td>
</tr>
<tr>
<td>A030872</td>
<td>immediately before A030906</td>
<td>NA</td>
<td>Claris</td>
<td></td>
</tr>
<tr>
<td>A030839</td>
<td>immediately before A030906</td>
<td>NA</td>
<td>Claris</td>
<td></td>
</tr>
<tr>
<td>A030840</td>
<td>immediately before A030906</td>
<td>NA</td>
<td>Claris</td>
<td></td>
</tr>
<tr>
<td>A030932</td>
<td>Immediately after A030906</td>
<td>NA</td>
<td>Claris</td>
<td></td>
</tr>
</tbody>
</table>

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*In Confidence*

Please note, the information in this summary is subject to change due to the nature of outbreak investigations.
### Table 2: Frequency of *Ralstonia* isolated from blood cultures, number of requests for blood culture and number that were positive

<table>
<thead>
<tr>
<th>State</th>
<th>Years</th>
<th>Number of <em>Ralstonia</em> blood isolate</th>
<th>Number of blood requests (years)</th>
<th>Number of blood requests positive for bacteria (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>Jan 2013 – March 2014</td>
<td>0</td>
<td>34,801 in Financial year (FY) 2012-2013</td>
<td>3603 (FY 2012-2013)</td>
</tr>
<tr>
<td>NT</td>
<td>2013-2014</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>2012</td>
<td>1</td>
<td>18,654</td>
<td>18,026</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAS</td>
<td>0 (Years?)</td>
<td>136,042 (2012)</td>
<td></td>
<td>156,665 (2013)</td>
</tr>
<tr>
<td>WA</td>
<td>2012 - 2014 (to date)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QLD</td>
<td>2011</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>NSW</td>
<td>1998</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2010-14 (to date)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The information in this summary is subject to change due to the nature of outbreak investigations.
Chapter 5.1

<table>
<thead>
<tr>
<th>VIC</th>
<th>2004-2013</th>
<th>2014</th>
<th>5</th>
<th>1</th>
<th>6060 (average per year, 2004 - 2012)</th>
</tr>
</thead>
</table>

**Genetic analysis of patient isolates**

Patient isolates were initially identified as *Haemophilus* species by culture and further analysed by Vitek or MALDI-TOF and 16S sequencing. Four QLD isolates, one VIC isolate and two isolates from SA were identified as *R. manitobalvica*, one SA isolate was identified as *R. picketti* and one QLD isolate was identified as *R. insidiosa*. All isolates were sent to QLD for Diavoid’s analysis, a rep-PCR (multiple PCRs of regions of the genome identified as variable enough for genotype differentiation) based system. The results of this analysis are shown in Figure 2.

![Figure 2. Diavoid results, including association with *prophol*.](image)

We have forwarded this section to QLD for comment as to whether details annotated in the last two columns on the right of Figure 2 (clonal grouping and identity), and interpretation of the % identity in the text below, are appropriate.

All the isolates from the GCUIH and RWH are similar (identities varying from 78% to 99%), and can be further split into two groups, each with a very high level of similarity. Clone 1 contains isolates from three patients, and has between 94% and 98% identity. This group has no isolates from blood culture, but one of the three patients did receive *prophol*. Clone 2 has ten isolates from four patients, with identity ranging from 93% to 99%. One of the isolates in Clone 2 is from the same patient as an isolate in the Clone 1. Of these four patients, three had positive blood cultures, while one (the patient who is also in the Clone 1) has a tracheal aspirate only. This patient did not receive *prophol*. These isolates are between 80% and 90% identical to an old isolate from TPCH from 2013. These isolates have all been identified by 16S sequencing as *R. manitobalvica*. In contrast, the recent isolate from TPCH, from a patient who has received *prophol*, shares only 50% to 58% identity with the other recent isolates from QLD, and has been

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Please note, the information in this summary is subject to change due to the nature of outbreak investigations.

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The three SA isolates show two distinct genotypes. The isolate from the private hospital shares 99% identity with one of the isolates from RAH (Clone 4). The second isolate from RAH shares only 69% identity with the other SA isolates. The former have been identified by 16S sequencing as *R. insidiosa*, whereas the latter was identified as *R. picketti*.

Interestingly, the *R. manitoulii* isolates from SA share only 56% and 75% identity with the *R. insidiosa* isolates from QLD (Clone 2), while these same SA isolates share between 72% and 77% identity with the *R. insidiosa* isolate from QLD. This is unexpected, because *R. manitoulii* isolates should be more genetically similar to other *R. manitoulii* than to *R. insidiosa* isolates. This shows a limitation of attempting to interpret DiverSeq lab data (patterns of PCR products) using the same framework as interpretation of genome sequencing.

The VIC isolate has the highest identity with the old TPCH isolate from 2013 (79%), but of the recent isolates from this outbreak, it is has the highest identity with the *R. manitoulii* isolates from SA (75%).

**Results of laboratory tests on propofol and vials**

Results of tests on 211 of the implicated vials are summarised in Table 3.

<table>
<thead>
<tr>
<th>Testing body</th>
<th>Number of vials</th>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGA</td>
<td>20</td>
<td>Sterility of contents and swabs of lid</td>
<td>Ongoing (negative so far)</td>
</tr>
<tr>
<td></td>
<td>2 (plus 6 vials from other batches)</td>
<td>Endotoxin</td>
<td>Negative</td>
</tr>
<tr>
<td>Claris Lifesciences</td>
<td>120</td>
<td>Swabs of outside and inside of lid</td>
<td>Ongoing</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Unknown</td>
<td>Endotoxin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sterility</td>
<td>Ongoing</td>
</tr>
<tr>
<td>SA Pathology</td>
<td>7</td>
<td>BACTEC test of contents</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>Lids and stoppers</td>
<td>Positive, see table 2</td>
</tr>
</tbody>
</table>

**Sample testing by TGA**

Eight different batches of propofol (including the two batches implicated in the initial report from SA, batches A030906 and A030907 plus batches A030021, A030146, A030293, A031266, A031267 and A040031), were tested for bacterial endotoxin by two different methods. All tests were complete and were negative for bacterial endotoxin. Batches A030906 and A030907 were also tested for bacterial contamination. Twenty vials of each of the implicated batches were tested for sterility. The test results are negative for contamination. The inside surface of the plastic flip cap and the surface of the rubber stopper of vials from both implicated batches was tested for contamination. The test results are negative for contamination.

SA has sent an additional 60 vials of each implicated batch. These have been tested for extrinsic contamination by swabbing the outside surface of the lid, and will be tested for...
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Contamination under the lid by swabbing the inside surface of the lid and the surface of the rubber stopper. Final results will be available on 6 June.

Sample testing by AMS Laboratories (for AFT Pharmaceuticals)
AMS Laboratories performed the same tests as TGA, on different batches of propofol (A631266, A031267 and A040081). All tests are still ongoing, but no growth has been detected so far.

Sample testing by Claris Lifesciences Limited (India)
The manufacturers tested retention samples of both batches implicated by SA, in addition to three batches manufactured immediately before these batches, and three manufactured immediately after. They also tested two batches of the Sandoz product. Endotoxin testing are negative, sterility testing will be complete on 26 May.

Sample testing by SA Pathology
The SA Pathology Microbiology Laboratory at RAH tested two implicated batches of propofol vials. Seven vials were tested for contamination by inoculating onto BACTEC aerobic blood culture bottles. This is a standard test for automated blood culture testing, and was used to identify the original patient isolates. Although the patient isolates grew within two days in this test, no growth was observed five days after inoculating with the propofol.

Sixty vials (four boxes [each containing 5 vials] from batch A030906 and eight boxes from batch A030907) were tested after “the outer surface of the lid & the neck of each vial were disinfected with 70% alcohol wipes”. The entire lid and swabs of the stopper surface were then placed into culture medium, pooled and cultured in groups of five. Results of the tests as of 13 May are shown in Table 4. Further sub-cultures, incubations and identifications are pending.

<table>
<thead>
<tr>
<th>Propofol batch</th>
<th>Lab Number</th>
<th>Results as at 13 May 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>A030906</td>
<td>90048212</td>
<td>Bacillus sp.</td>
</tr>
<tr>
<td></td>
<td>90048217</td>
<td>No growth; cultures proceeding</td>
</tr>
<tr>
<td></td>
<td>90048215</td>
<td>Bacillus sp.</td>
</tr>
<tr>
<td></td>
<td>90048207</td>
<td>scant growth, cultures proceeding</td>
</tr>
<tr>
<td>A030907</td>
<td>90048208</td>
<td>GNB for ID – phenotypically not <em>G. staphylococcus</em></td>
</tr>
<tr>
<td></td>
<td>90048214</td>
<td>CNS</td>
</tr>
<tr>
<td></td>
<td>90048218</td>
<td>scant growth, cultures proceeding</td>
</tr>
<tr>
<td></td>
<td>90048216</td>
<td>Bacillus sp.</td>
</tr>
<tr>
<td></td>
<td>90048213</td>
<td>scant growth, cultures proceeding</td>
</tr>
<tr>
<td></td>
<td>90048211</td>
<td>No growth; cultures proceeding</td>
</tr>
<tr>
<td></td>
<td>90048209</td>
<td>R. manitolitica (MALDI ID 2.11)</td>
</tr>
</tbody>
</table>

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Please note the information in this summary is subject to change due to the nature of outbreak investigations.

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The SA Pathology Microbiology Laboratory report stated: “This laboratory has NATA accreditation for human diagnostic work and sterility testing of bronchoscopes but does not hold extensive NATA environmental-testing accreditation. The methodology was specifically adapted in-house to test these proposed vials. The method has not been fully validated and results should be interpreted accordingly. ... The technician attempted to use sterile technique but the removal of the vial lids was difficult. Contamination may have been introduced during sampling as evidenced by the mixture of cutaneous flora in the sub-cultures. With that caveat, an isolate of *R. nonpathogenic* has been obtained from an implicated box of proposed (A030907).” This isolate was included in the results of the Diversilab analysis and is identical to the two clinical isolates from the RAH and the private hospital in SA (Figure 2).

SA Pathology have provided vials from these two batches to TGA for additional testing under NATA certified conditions. Diversilab analysis shows that this isolate is identical to the Group 3 isolates from SA (Figure 2).

**Manufacturers report**

The TGA has received information from the manufacturer documenting manufacturing and sterilisation procedures for batches A030906 and A030907. The report prepared by TGA concludes that the sterile manufacturing processes for these batches were in accordance with the processes registered for the product; and the batches comply with the regulatory requirement for terminally sterilised product, i.e. that the theoretical probability of there being a viable microorganism present in the product shall be equal to or less than $1 \times 10^{-6}$.

**Outstanding action items**

1. TGA to complete testing all samples
2. QLD to do whole genome sequencing on all samples (as documented in minutes of the CDNA-WG on 19 May)
3. SA to provide details on investigations to assess possible common sources of infection for the three cases reported in the two hospitals
4. Consider extent of a HACCP investigation (Hazard analysis of critical control points) required (release of proposed from the factory to the level of distribution to the clinical units where proposed was administered)
5. Manufacture dates of all implicated batches to be obtained (refer to Table 1), and if possible

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Appendix 4: ProMED alert – *Ralstonia pickettii*, sepsis – Australia: contaminated propofol, alert 22 May 2014

**Published Date:** 2014-05-22 02:52:11
**Subject:** PRO/EDR> Ralstonia pickettii, sepsis - Australia: contaminated propofol, alert
**Archive Number:** 20140522.2489978

**RALSTONIA PICKETTII, SEPSIS - AUSTRALIA: CONTAMINATED PROPOFOL, ALERT**

A ProMED-mail post
http://www.promedmail.org
ProMED-mail is a program of the International Society for Infectious Diseases
http://www.isid.org

[1]
**Date:** Tue 20 May 2014
**From:** Claire Behm <si.coordinator@tga.gov.au> [edited]

Increase in cases of ralstonia bacteremia associated with propofol in Australia

The Therapeutic Goods Administration of Australia (TGA) is gathering information about cases with ralstonia bacteremia that are potentially related to administration of propofol.

A multi-jurisdictional investigation has identified 8 cases of ralstonia bacteremia with a common link to administration of propofol. The most recent Australian case was reported on 4 May 2014.

Investigations are ongoing. We look forward to hearing if colleagues in other countries have noticed any unusual increase in clinical isolations of ralstonia associated with propofol or other medical products or devices.

--

Dr Claire Behm
Signal Investigation - Medicines
Office of Product Review
Therapeutic Goods Administration
Australia
<si.coordinator@tga.gov.au>

[ProMED-mail thanks Dr Behm for bringing this outbreak to our attention. - Mod.ML]

*****

[2]
**Date:** Fri 9 May 2014
**Source:** Australian Government, Department of Health, Therapeutic Goods Administration (TGA) [edited]

Health professionals, hospitals and health facilities are advised that batches of a widely used intravenous anaesthetic drug, propofol, may include some vials that have been contaminated with the bacteria *Ralstonia pickettii*. There have been reports of patients having developed sepsis following administration of 1 per cent propofol injection.

In consultation with the TGA, the Australian distributor of Proviive MCT-LCT per cent (propofol 1 per cent) emulsion for injection in 10 ml vials (ARTG 162318), AFT Pharmaceuticals, has quarantined 2 batches due to potential contamination with *Ralstonia pickettii*. The affected batch numbers are:
A030996 (expiry date 06/15)
A030997 (expiry date 06/15).
At this time, no batches of any of the drugs listed below are subject to a recall.

As a precautionary measure, health professionals are advised, where possible, to avoid use of all sizes and all batches of the AFT-distributed Prorieve and Sandoz Propofol 1 per cent products as listed below pending further investigation into this issue:

ARTG: ARTG Label
116940: Claris Lifesciences Australia Pty Ltd PROVIVE 1 per cent propofol 1000mg/100mL emulsion for injection vial (distributed by AFT)
116938: Claris Lifesciences Australia Pty Ltd PROVIVE 1 per cent propofol 200mg/20mL emulsion for injection vial (distributed by AFT)
162319: PROVIVE MCT-LCT 1 per cent propofol 500mg/50mL emulsion for injection vial (distributed by AFT)
116939: Claris Lifesciences Australia Pty Ltd PROVIVE 1 per cent propofol 500mg/50mL emulsion for injection vial (distributed by AFT)
162320: PROVIVE MCT-LCT 1 per cent propofol 1000mg/100mL emulsion for injection vial (distributed by AFT)
162318: PROVIVE MCT-LCT 1 per cent propofol 200mg/20mL emulsion for injection vial (distributed by AFT)
140870: PROPOFOL SANDOZ propofol 200mg/20mL emulsion for injection vial
140872: PROPOFOL SANDOZ propofol 1000mg/100mL emulsion for injection vial
140871: PROPOFOL SANDOZ propofol 500mg/50mL emulsion for injection vial

Hospitals should consider seeking alternative sources of propofol 1 per cent to the drugs listed above. Where there are no suitable alternatives, health professionals should satisfy themselves that the benefits outweigh the risks to the patient.

... _Ralstonia pickettii_ are Gram negative bacteria. It may take several days for a blood culture to become positive and may be difficult for a laboratory to identify. Possible initial identifications include _Stenotrophomonas_-, _Burkholderia_-, and _Pseudomonas_ species of bacteria.

This medicine is only used in hospitals and certain health facilities. Hospitals and health facilities have been contacted and provided further information about this issue, including details of the quarantine process. If you have any questions or concerns about this issue, talk to your health professional.

TGA investigations

The TGA is working with state and territory health departments to gather further information regarding the reported cases of sepsis and to identify the specific organism(s) suspected of causing the infection. In particular, the TGA is investigating the strength of the evidence linking these propofol products with the reported cases of sepsis.

As part of these investigations, the TGA is testing samples of the affected batches for microbial quality. This testing includes performing sterility and bacterial endotoxin tests on the products. Results from the sterility testing will not be available for 2-3 weeks due to the prolonged incubation period for this test and the nature of the product. The bacterial endotoxin test is a quicker test, but is limited in that it only detects a component of some bacterial cells. Preliminary results from this test to date do not indicate the presence of bacterial endotoxin.

The TGA is also carefully examining the manufacturing site data to identify relevant information.

Reporting problems

Consumers and health professionals are encouraged to report problems with medicines or vaccines. Your report will contribute to the TGA’s monitoring of these products. The TGA cannot give advice about an individual’s medical condition. You are strongly encouraged to talk with a health professional if you are concerned about a possible adverse event associated with a medicine or vaccine.

--
communicated by: ProMED-mail
<promed@promedmail.org>

******

Date: Mon 12 May 2014
This is an update to the chief health officer alert dated 2 May 2014 for suspected contamination of "ProVive" propofol. A number of people across Australia have developed septicemia due to Ralstonia species with a common link of having been administered ProVive propofol in April 2014. Further investigations are being undertaken by the Therapeutic Goods Administration (TGA) to determine the cause of sepsis and the strength of evidence linking propofol products with reported cases.

The TGA recommendation to quarantine the 2 suspect batches of propofol remains. At this time, no batches of any of the drugs listed below are subject to a recall. Hospitals should quarantine stock of ProVive and Sandoz propofol products and continue to seek alternatives to ProVive and Sandoz propofol products until further notice. Maintain a high index of suspicion in all febrile patients following intravenous sedation or anaesthesia. Report any potential cases of sepsis following administration of ProVive propofol to the TGA and the Department of Health.

Ralstonia pickettii is a rare infection. It is a Gram negative organism that has been linked in the past to contamination of medical therapeutic agents. Concern was raised when this organism was identified in 3 South Australian patients who had procedures in April 2014. The only common exposure was the administration of ProVive propofol during their procedures.

Five cases of septicemia due to Ralstonia species where ProVive propofol was also administered were subsequently identified in Queensland (4) and Victoria (1). Additional cases of septicemia due to Ralstonia species have also been identified where there was no link to propofol administration.

The TGA is working with state and territory health departments to gather further information regarding the reported cases of sepsis to identify the specific organism(s) suspected of causing the infection. In particular, the TGA is investigating the strength of the evidence linking these propofol products with the reported cases of sepsis.

As part of these investigations, the TGA is testing samples of the suspect batches for microbial quality. This testing includes performing sterility and bacterial endotoxin tests on the products. Results from the sterility testing will not be available for 2-3 weeks due to the prolonged incubation period for this test and the nature of the product. The TGA is also carefully examining the manufacturing site data to identify relevant information.

All patients undergoing anaesthesia or sedation involving the suspected batches of propofol are potentially at risk. Affected persons have developed rapid onset of fever and signs of septicemia following medical procedures involving the suspected batches of propofol. Some have required admission to intensive care.

Medical practitioners should avoid using the following batches of propofol: ProVive MCT-LCT 1 per cent 20 ml vials, batches A030966 Exp. 08/15, and A030907 Exp. 08/15 because of the potential risk of septicemia. As a precaution it is recommended that all practitioners avoid using any ProVive propofol products. Because the same manufacturer and supplier are used by Sandoz, clinicians should also avoid the use of Sandoz propofol products. Hospitals should seek alternatives to these brands.

Sandoz and ProVive propofol products should only be used where there is no suitable alternative and consideration is given to the benefit relative to the risk to the patient.

Hospitals and other treatment facilities should check their stocks of propofol for the identified products and quarantine these immediately.

Maintain a high index of suspicion in all febrile patients following intravenous sedation or anaesthesia.

For any suspected case, consider the following actions: take blood cultures; check whether there was an exposure to a product of concern; seek advice from an Infectious diseases physician. If you become aware of any potential cases of sepsis following administration of ProVive propofol, contact the TGA at: <advsreports@tga.gov.au> or on 1300 044 114. Notify suspected cases immediately to the Communicable Disease Prevention and Control section at the Department of Health on 1300 651 160.
Propofol is a short-acting, intravenously administered hypnotic/anesthetic agent that is used for induction and maintenance of general anesthesia, sedation for mechanically ventilated adults, and procedural sedation. Propofol is approved for use in more than 50 countries, and generic versions are available.

Although it may contain antimicrobial agents (EDTA, sodium metabisulfite, or benzoic alcohol), propofol is a soybean oil emulsion that can still support the rapid growth of microorganisms (https://www.fda.gov/Drugs/DrugSafety/PostmarketDrugSafetyInformationforPatientsandProviders/ucm125817.htm). Microbial contamination, however, may not be readily appreciated because its intravenous preparation has a milky highly opaque appearance.

In 1995, an outbreak that involved 62 patients with post-operative infections caused by Staphylococcus aureus, Candida albicans, Moraxella osloensis, Enterobacter aerogenes, or Serratia marcescens at 7 hospitals in 4 states over a several-year period was traced to contaminated propofol (http://www.aulisindice.com/curso_infecciones_asociadas/pdf/F21_contaminacion_propofol.pdf). In 2007, the US FDA cited several clusters of patients who experienced chills, fever, and body aches shortly after receiving propofol for sedation or general anesthesia and noted that some facilities where the propofol was administered used single-patient use vials of propofol for more than one patient.

The FDA recommended that healthcare professionals who administer propofol carefully follow the recommendations in the product labeling: To minimize the potential for bacterial contamination when using propofol for general anesthesia or procedural sedation, both the vial and prefilled syringe formulations must be used on only one patient; administration must commence immediately after the vial or syringe has been opened; and administration from a single vial or syringe must be completed within 6 hours of opening. ICU sedation with propofol administered directly from a vial must be limited to only one patient, must commence immediately on opening the vial, and must be completed within 12 hours of opening the vial to minimize the risk of product contamination.

In 2009, lots of propofol were recalled in the US because of contamination with bacterial endotoxin after 41 propofol-treated patients were reported to have experienced postoperative fever, chills, and other flu-like symptoms (http://www.medsenet.com/newsalert/Prescriptions/15134). In 2010, sepsis due to Klebsiella pneumoniae and Serratia marcescens, which developed in 2 patients in the Netherlands following relatively minor surgical procedures, was attributed to contaminated propofol (http://www.ncbi.nlm.nih.gov/pubmed/20170064 and http://www.ncbi.nlm.nih.gov/pubmed/20632067).

ProMED-mail previously posted a report of nosocomial transmission of hepatitis B and hepatitis C virus that involved reuse of syringes to re-dose patients, which contaminated a single-use vial of propofol that was used for multiple subsequent patients undergoing endoscopy (see Hepatitis B & C, physician-related cluster - USA 20100731.2332).

Ralstonia pickettii (formerly called Pseudomonas pickettii or Burkholderia pickettii) are nonfermentative Gram negative rod-shaped bacteria that grow well in moist environments such as soils, river and lakes. (https://cid.oxfordjournals.org/content/79/3/928.full). They are emerging nosocomial pathogens, causing infection in compromised hosts, which have been attributed to contaminated solutions such as water, saline, and sterile drugs. These solutions are usually contaminated when the product is manufactured, due to the fact that _R. pickettii_ have the ability to pass through 0.2 micron filters that are used to sterilize medicinal products (http://www.pharmaceuticalonline.com/doc/proper-lr-micron-pes-filters-0001). Infections include bacteremia/septicaemia, meningitis, septic arthritis, and osteomyelitis (http://www.ncbi.nlm.nih.gov/pubmed/16137399). - Mod.ML.

A HealthMap/ProMED-mail map can be accessed at: http://healthmap.org/promed/p/186.
Appendix 5: Focused literature review assessing the level of contamination that could be expected in the propofol solution at the time of administration if the propofol solution had been contaminated at the point of manufacture many weeks or months earlier

Abstract

Study Objective

To review the literature to assess the level of contamination that could be expected in the propofol solution at the time of administration if the propofol solution had been contaminated at the point of manufacture many weeks or months earlier.

Methods

We searched PubMed for publications on the growth characteristics of Ralstonia spp. in propofol using specific questions and search terms to guide the search. The Boolean logical operator ‘AND’ was used to link search terms and the Boolean wildcard character ‘*’ was used to find variations on the search terms grow(th)*, charact*, inhibit* and bacteria*. The species’ previous names (Burkholderia and Psuedomonas) were also included in the search terms.

Main Results

We included nine studies in this review because they all provided information on the growth of bacteria that are biochemically similar to Ralstonia spp. in propofol. We could not access four studies. Of these studies, two showed that propofol supported the growth of bacteria including P. aeruginosa and one study did not provide information on the growth of P. aeruginosa in the propofol alone (1). The fourth publication was a case report but provided no information on the growth characteristics of P. aeruginosa propofol (2).

Conclusions

Seven of the nine publications showed that propofol not only supports microbial growth, but results in rapid multiplication. These findings show that if the propofol was contaminated with Ralstonia spp. at the point of manufacture, we could expect the vials to have been heavily contaminated with Ralstonia spp. by the time it was drawn up for clinical use many weeks later.
1. Introduction

Between April and May of 2014, an unusual increase in the number of cases with *Ralstonia* bacteraemia was reported from six hospitals in three Australian states. Initial investigations suggested the source of the *Ralstonia* species was propofol because only people administered the drug developed the infection. A multijurisdictional investigation could not find evidence that the propofol solution was contaminated with *Ralstonia* spp., although the flip off caps and external surface of the rubber stoppers of some propofol vials were contaminated with multiple bacterial species including *R. mannitolylitica*; the latter isolate was 97% identical on DiversiLab® analysis and genetically indistinguishable using whole genome sequencing to clinical isolates of *R. mannitolylitica* from two of the cases.

*Ralstonia* spp. previously known as *Pseudomonas* (3, 4) and *Burkholderia* (4, 5) are a large group of gram negative, aerobic bacteria that are emerging as opportunistic pathogens. They are found in soil and different water sources (6) including municipal drinking supplies (7), bottled mineral water (8), hospital water supplies (9), laboratory-based high purity water systems (10), industrial ultra-pure/high-purity water (11-13) and space shuttle water systems (14). They are hardy organisms capable of surviving a wide range of disinfectants and antimicrobials (15). *R. Pickettii, R. insidiosa* and *R. mannitolylitica* have been isolated from a variety of clinical specimens including blood, urine and cerebrospinal fluid (16), and lung sputum of cystic fibrosis patients (17, 18).

*Propofol* (2,6-diisopropylphenol) is a widely used general anaesthetic and approximately 4,806 vials of Provive propofol 1% solution are used across Australia each day (19). *Propofol* is a lipid-based, emulsion containing glycerol, purified egg phosphatide, sodium hydroxide, and soya bean oil (20) and provides an excellent growth medium for a variety of gram positive and negative bacteria, and yeasts (1, 21-43). Although Ethylenediaminetetraacetic acid (EDTA) is added to the solution as an antibacterial agent, its effectiveness has been questioned (44, 45).

For this study, we reviewed the literature to assess the level of contamination that could be expected in the propofol solution at the time of administration if the propofol solution had been contaminated at the point of manufacture many weeks or months earlier.

2. Methods

We searched PubMed for publications on the growth characteristics of *Ralstonia* spp. in propofol using specific questions and search terms to guide the search, as detailed in Table 1. The Boolean logical operator ‘AND’ was used to link search terms and the Boolean wildcard character “*” was used to find variations on the search terms grow(th)*, charact*, inhibit* and bacteria*. The species’ previous names (*Burkholderia* and *Pseudomonas*) were also included in the search terms.

The title and abstract for each of the references was reviewed. Articles that provided information on the growth of bacteria biochemically similar to *Ralstonia* spp. in propofol were included.
Table 1: Results of the literature search for specific questions and search terms using PubMed

<table>
<thead>
<tr>
<th>Specific question</th>
<th>Search terms</th>
<th>No. of publications identified</th>
<th>No. of publications included</th>
<th>No. of publications excluded</th>
<th>No. could not access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does propofol solution support the growth of Ralstonia?</td>
<td>1. Grow* AND Ralstonia AND Propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2. Ralstonia AND propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3. Grow* AND Propofol AND Pseudomonas</td>
<td>14</td>
<td>9</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4. Grow* AND Propofol AND Burkholderia</td>
<td>2 (already identified in search 3)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Does propofol solution inhibit the growth of Ralstonia?</td>
<td>5. Ralstonia AND inhib* AND growth AND Propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6. Ralstonia AND inhib* AND Propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>7. Pseudomonas AND inhib* AND growth AND Propofol</td>
<td>7 (already identified in search 3)</td>
<td>4</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>8. Pseudomonas AND inhib* AND Propofol</td>
<td>This search produces the same results as 7. above.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Burkholderia AND inhib* AND growth AND Propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10. Burkholderia AND inhib* AND Propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>What are the growth characteristics of Ralstonia in propofol?</td>
<td>11. Grow* AND charact* AND Ralstonia AND propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12. Grow* AND charact* AND Pseudomonas AND propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13. Grow<em>AND charact</em> AND Burkholderia AND propofol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
3. Results

We included nine studies in this review (21, 23, 30, 45-49). We could not access four studies (1, 2, 50, 51). Of these, three (1, 50, 51) investigated the growth of a variety of organisms (including *P. aeruginosa*) in propofol, and investigated the antimicrobial effects of propofol mixed with other solutions. Overall, from the abstracts, two studies showed that propofol supported the growth of bacteria including (*P. aeruginosa*) (50, 51) and one abstract did not provide information on the growth characteristics of *P. aeruginosa* in propofol (1). Brief summaries of the abstracts are provided below. The fourth publication was a report on a case that developed septic shock after receiving cosmetic surgery. Blood cultures of the case were positive for *P. cepacia* and contamination of propofol was suspected, but no further details were given (2).

Harvey et al., 2003 evaluated the growth of 4 different microorganisms (one of which was *P. aeruginosa*) in propofol, methohexital (an intravenous anaesthetic that may be used for induction of anaesthesia), and 1:1 and 1:3 mixtures if propofol and methohexital. They found that combining Diprivan or generic propofol with methohexital in a 1:1 or 1:3 mixture ratio resulted in a solution that (like methohexital alone) inhibited growth of *P. aeruginosa* for 48 hours. Further information on the growth of *P. aeruginosa* in the propofol only solution was not available in the abstract (1).

Joubert et al., (2005) assessed bactericidal properties of serial mixtures of propofol and thiopentone and found that propofol supported the growth of all organisms tested (including *P. aeruginosa*). They also found that mixtures of propofol and thiopentone at a ratio less than 1:1 did not retain bactericidal properties (50). Further information on the growth of *P. aeruginosa* was not available in the abstract.

Keles et al., (2006) assessed the antimicrobial effects of dexmedetomidine and etomidate-lipuro, and to compare these effects with those of midazolam and propofol on a range of bacteria including *P. aeruginosa*. They found Midazolam inhibited the growth of bacteria but that propofol had no antimicrobial effects on the organisms tested (including *P. aeruginosa*) (51).

**Growth of Pseudomonas aeruginosa in propofol**

Inoculates of 1-2 x 10^5 *Pseudomonas aeruginosa* (ATCC 27853) (Oxoid/UK) per ml into 1% propofol (Propofol® % 1 Fresenius) were incubated at 35°C for 24 hours. After an initial lag time of 2 hours, *P. aeruginosa* grew exponentially reaching ≥ 1 x 10^5 colony forming units per millilitre (cfu.ml^-1) at 8 hours (Figure 1). The cfu.ml^-1 count at 24 hours was not reported (46).
Figure 1: Growth rates of *P. aeruginosa* (and other organisms tested) in 1% propofol solution in 2-hour periods (46)\(^1\)

Guzelant et al., (2008) inoculated 4 x 10\(^5\) cfu.ml\(^{-1}\) of *P. aeruginosa* (clinical isolate) into propofol (Pofol\(^\circledast\) 1%; Dongkook pharmaceutical Co., South Korea) at 35°C and found 59 x 10\(^{-2}\) colonies at five hours and >1,000 x 10\(^{-2}\) at 24 hours post inoculation (47).

Ravenelle et al., (2008) inoculated 10\(^4\) cfu/ml of *P. aeruginosa* (ATCC 6538) into Diprivan\(^\circledast\) (Astra Zeneca) and incubated at 35°C. Twenty-four hours post inoculation the authors counted >35 x 10\(^3\) cfu/mL. This study also reported that EDTA (a microbial growth retardant) present in Diprivan\(^\circledast\) controlled microbial growth for the first few hours, but was then superseded by a period of exponential growth (48).

Apan et al., (2007) also found exponential growth of *P. aeruginosa* 24 hours post inoculation into propofol (21). The authors inoculated 5 x 10\(^5\) colonies of *P. aeruginosa* (ATCC 50143) into propofol (type not stated) for 24 hours at 37°C. Results are shown in Figure 2.

\[^1\] I will request permission from the publishers to include all figures in this publication.
Another study showed, that 24 hours post inoculation, *P. aeruginosa* (ATCC 27853) increased from an initial inoculation of $5 \times 10^{5}$ cfu/mL to $>5,000$ CFUs (45) in propofol (Deprivan 1%; Zeneca Pharmaceuticals, Wilmington, DE).

Berry et al. (1993) inoculated propofol (Diprivan ICI) with *P. aeruginosa* (NCTC 10662) with a concentration of $10^{3}$ cfu.ml$^{-1}$ and allowed the bacteria to grow at 20°C and 37°C. The growth of the bacteria was measured at 6, 12 and 24 hours. At 20°C a 10-fold increase was recorded at 6 hours, and $10^{5}$ -fold increase was recorded at 24 hours. At 37°C, a $10^{3}$ -fold increase occurred at 6 hours, and a $10^{7}$ -fold increase occurred at 24 hours. Viable organisms of *P. aeruginosa* were still obtained from the propofol solution at 7 days post inoculation after being incubated at 4°C (23).

Holroyd et al., (2014) investigated the efficacy of a new intravenous cleaning device compared with 70% isopropyl alcohol prep pads. They contaminated a variety of devices and used contaminated propofol as a control. After inoculation with 0.5 McFarland standard of *P. aeruginosa* (ATCC 27853), they also found exponential growth after 24 hours of incubation (49).

These studies were further supported by a letter to the editor which reported that *P. aeruginosa* (ATC 27853) grew ‘vigorously’ in 1% propofol after incubation for 24 hours (52). No further details were given.

**Growth of Burkholderia cepacia in propofol**

Obayashi et al. (2003) found rapid proliferation of *Burkholderia cepacia* (clinical isolate) at 30 °C in propofol (Diprivan 10mg/ml) over a seven day period (Figure 3) (30).

![Figure 3: Viability of *S. marcescens* at 30 °C in Soybean Oil (O) and propofol (Δ) and of *B. cepacia* at 30 °C in Soybean Oil (□) and Propofol (▽)](image3)

5.1-50
In contrast to these studies however, two studies (24, 35) reported that propofol had weak bactericidal effects on the growth of *P. aeruginosa*. Crowther et al., (1996) inoculated *P. aeruginosa* (ATCC 27853) into propofol (Diprivan®; Zeneca Pharma, Mississauga, Ontario, Canada) vials and then the vials were sub plated out at 0, 3, 6, 12 and 42 intervals and stored at 20°C between samplings. The plates were then incubated at 35°C for 24 hours to find a modest decrease in growth of *P. aeruginosa* (Figure 4) (24).

![Figure 4](image1)

**Figure 4:** Number of colony forming units of *Pseudomonas aeruginosa* counted over a 24 hour period after inoculation in various agents (24)

Wachwoski et al., (1999) used a similar methodology, similar strain of *P. aeruginosa* (ATCC 27853) and a similar brand of propofol (Diprivan®; Zeneca Pharma, Mississauga, Ontario, Canada) to that reported by Crowther (24), and also reported a decline in growth of *P. aeruginosa* 24 hours post inoculation (Figure 5) (35).

![Figure 5](image2)

**Figure 5:** Number of colony-forming units of *Pseudomonas aeruginosa* counted over 24 hours after inoculation in various mixtures. *P <0.05 significantly different from baseline (time 0). P = propofol (35).
4. Discussion

Seven of the nine publications identified in this review showed that propofol not only supports microbial growth, but results in rapid multiplication (21, 23, 30, 45-48).

Propofol is a lipid-based, emulsion containing glycerol, purified egg phosphatide, sodium hydroxide, and soya bean oil (20) and thus provides an excellent growth medium for a variety of gram positive and negative bacteria, and yeasts including P. aeruginosa (1, 21-25, 27-37). The manufacturer’s guidelines therefore recommend that strict aseptic technique should be used when handling and administering propofol (53-55).

Two studies (24, 35) however reported that propofol had a weak bactericidal effect on the growth of P. aeruginosa. The main difference between this study and the six of the seven studies that reported exponential growth of P. aeruginosa or B. cepacia is that both Crowther et al., (1996) and Wachowski et al., (1999) stored the samples at 20°C between sampling times, whereas the other studies incubated their samples at higher temperatures: 30°C (30), 35°C (46-49) and 37°C (21, 45). The optimal range for growth of P. aeruginosa is 37°C (range 4°C to 42°C) (56). It is possible that the lower temperature that Crowther and Wachowski’s samples were stored at slowed down the growth of P. aeruginosa, however Berry at al., (1993) also stored their samples at 20°C and showed exponential growth of P. aeruginosa by 24 hours (23). However, there were many differences between Berry, Wachowski and Crowther’s studies which could be related to the differences in results. The main obvious differences are that different strains of P. aeruginosa were used: Berry et al., (1993) used P. aeruginosa (NCTC 10662) and Crowther et al., (1996) and Wachowski et al., (1998) used P. aeruginosa (ATCC 27853), and different propofol solutions were used: Berry et al., (1993) used Diprivan (ICI) and Crowther et al., (1996) and Wachowski et al., (1998) used Diprivan® (Zeneca Pharma, Mississauga, Ontario, Canada).

We are not certain why these two studies present conflicting findings, however, the majority of the evidence shows that propofol supports exponential growth of biochemically similar bacteria to Ralstonia spp.

It is possible that we missed publications by not searching other search engines such as MEDLINE, however we would have expected that if there were additional publications they would have been identified through cross referencing or ‘suggested articles’ on the PubMed.

5. Conclusion

These studies suggest that if the propofol were contaminated with Ralstonia spp. at the point of manufacture, we could expect the vials to have been heavily contaminated with Ralstonia spp. by the time it was drawn up for clinical use many weeks later.
References


## Appendix 6: Line list of cases of *Ralstonia* bacteraemia

<table>
<thead>
<tr>
<th>Hospital*</th>
<th>Diagnosis</th>
<th>Adm date</th>
<th>Day/time propofol first administered</th>
<th>Day/time of onset of infection</th>
<th>Incubation period</th>
<th>Species</th>
<th>Diversilab result (same colour for identical strains)</th>
<th>Possible batches (date of manufacture)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vict, ENDO</td>
<td>Colonoscopy - polypectomy, acupuncture needles in situ 27/3 to 3/4</td>
<td>1/4</td>
<td>1/4 13:10</td>
<td>1/4 18:00</td>
<td>5 hours</td>
<td><em>R.mann</em></td>
<td>Diff to all other isolates</td>
<td>Batch numbers unknown, could be up to 4 different batches</td>
</tr>
<tr>
<td>SA Private hospital, ENDO</td>
<td>Upper endoscopy and colonoscopy, metastatic cancer (diagnosed for the first time). CT scan with IV contrast on 1/4/2014</td>
<td>17/4</td>
<td>17/4 14:35</td>
<td>17/4 16:10</td>
<td>2 hours</td>
<td><em>R.mann</em></td>
<td>Identical to 1 strain from RAH</td>
<td>Provive batches: A030906 (09/2013) A030907 (09/2013) (3 other batches may also be implicated)</td>
</tr>
<tr>
<td>RAH, ICU</td>
<td>Motor vehicle accident, multiple opportunities for infection in ICU since 13/4</td>
<td>13/4</td>
<td>13/4  Infusion started in the morning</td>
<td>18/4 9:00</td>
<td>5 days</td>
<td><em>R.mann</em></td>
<td>Ident SA priv</td>
<td>Provive batches: A030906 (09/2013) A030907 (09/2013)</td>
</tr>
<tr>
<td>RAH, ICU</td>
<td>Subarachnoid hg, multiple opportunities for infection in ICU since 20/4</td>
<td>20/4</td>
<td>20/4 time unspecified</td>
<td>23/4 16:00</td>
<td>3 hr &lt;4 days</td>
<td><em>R.pick</em></td>
<td>Diff to all other isolates</td>
<td>Provive batches: A030906 (09/2013) A030907 (09/2013)</td>
</tr>
<tr>
<td>Location</td>
<td>Description</td>
<td>Admission Date</td>
<td>Readmission Date</td>
<td>Time</td>
<td>Time</td>
<td>Identification</td>
<td>Strain Identification</td>
<td>Provive Batches</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>----------------</td>
<td>------------------</td>
<td>------</td>
<td>------</td>
<td>----------------</td>
<td>-----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>TPCH, ICU</td>
<td>Influenza pneumonia, respiratory failure, ICU since 15/4</td>
<td>15/4</td>
<td>17/4</td>
<td>4/5</td>
<td>7 days</td>
<td><em>R. ins</em></td>
<td>Different to all other isolates</td>
<td>Sandoz batches: A031110 and A030504</td>
</tr>
<tr>
<td>RBWH</td>
<td>Interhospital transfer from TPCH with AML</td>
<td>29/5</td>
<td>N/A</td>
<td>15/6</td>
<td>Unknown</td>
<td><em>R. mann</em></td>
<td>Strain ident to RBWH &amp; GCUH</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*ENDO = endoscopy ward, OT = operating theatre, ICU = intensive care unit*
Appendix 7: Original *Ralstonia* case report form developed by Queensland Department of Health

<table>
<thead>
<tr>
<th>Case name</th>
<th>First name</th>
<th>Last name</th>
<th>DOB</th>
<th>ID</th>
</tr>
</thead>
</table>

**Ralstonia Case Report Form**

For all *Ralstonia* (including but not limited to *Ralstonia pickettii*, *Ralstonia pickettii* and *Ralstonia pickettii*) cases, please collect data for one month prior to first isolation of *Ralstonia* or subsequent, whichever is longer. If more than one admission in the month prior to isolation (including admission back to month) on separate case report forms.

**Patient Information**

<table>
<thead>
<tr>
<th>Name</th>
<th>UR No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
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<table>
<thead>
<tr>
<th>Date of birth</th>
<th>Age</th>
<th>Years</th>
<th>Months</th>
<th>Sex</th>
<th>Male</th>
<th>Female</th>
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</table>

<table>
<thead>
<tr>
<th>Home of patient</th>
<th>Age</th>
<th>Years</th>
<th>Months</th>
<th>Sex</th>
<th>Male</th>
<th>Female</th>
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</thead>
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<table>
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<tr>
<th>English preferred language</th>
<th>Yes</th>
<th>No</th>
<th>Specify</th>
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<table>
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<tr>
<th>Residential address</th>
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<tr>
<th>Home phone</th>
<th>Work phone</th>
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</table>

<table>
<thead>
<tr>
<th>CLINICAL DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason for hospital admission</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hospital Admission date</th>
<th>Discharge date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Hospital ward/ICU</th>
<th>Admission date</th>
<th>Discharge date</th>
</tr>
</thead>
</table>

Was the patient immunocompromised? | Yes | No | Unknown |

Did the patient have diabetes? | Yes | No | Unknown |

Did the patient have a dialysis? | Hemodialysis | Peritoneal dialysis | No |

Other medical history:

<table>
<thead>
<tr>
<th>Other medical history</th>
<th></th>
<th></th>
</tr>
</thead>
</table>

**Laboratory**

<table>
<thead>
<tr>
<th>Culture date and site</th>
<th>Result</th>
<th>Comment including all suspected micro-organism(s)</th>
</tr>
</thead>
</table>

**Clinical Procedures**

List of clinical procedures performed ONE month prior to isolation of *Ralstonia pickettii*.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Category</th>
<th>List of complex wounds and dressing used</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Device(s) (e.g. IV cannula, PORT, PKC, CVC, Haemodialysis catheter, etc.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of device</td>
<td>Insertion date</td>
</tr>
</tbody>
</table>

5.1-59
Chapter 5.1

MEDICATIONS:
List of all non-oral medications administered to the patient, e.g. IV, E/C, E/A, flushes, IV fluids, IV medications, nebulisers, inhalers, topical, bladder irrigation, etc.

PLEASE NOTE: SPECIFICALLY REPORT USE OF PROPOLIS AND FRUSEMIDE

<table>
<thead>
<tr>
<th>Name of medications</th>
<th>Name of medications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

COMPLICATIONS:
☐ Yes – specify ___________________________ ☐ No

Outcome of 14 days following initial isolation:
☐ Survived ☐ Died Date of death: __________

☐ Died directly of Pseudomonas ☐ Yes ☐ No ☐ Unknown

Outcome of subsequent cultures:

<table>
<thead>
<tr>
<th>Culture date and site</th>
<th>Result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CLINICAL TREATMENT AND OUTCOMES:
List of treatment administered for positive isolate of Pseudomonas

<table>
<thead>
<tr>
<th>Name of medications/antibiotics</th>
<th>Dose</th>
<th>Start date</th>
<th>Stop date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

May 2014 5 of 4
Appendix 8: Adapted Ralstonia case report form for multijurisdictional investigation into cases of Ralstonia bacteraemia 1 April to 26 June 2014

For ALL Ralstonia (excluding but not limited to R. picketti, R. picketti, and R. picketti not cutaneous)
*Completed by: ____________________________  Date sent to CDU: ____________
*Telephone: ____________________________

Please complete this form for each person known to have bacteraemia due to any Ralstonia species since Jan 2014
*Questions are considered high priority for the TSB epidemiological investigation

Patient Information:
- Name:
- Patient ID (eg initials):
- Date of birth: Year: ______  Month: ______  Day: ______  Age: ______
- Sex: ______  Male  ______  Female
- Home of permanent residence:
  - Aboriginal  ______  Torres Strait Islander  ______  Other  ______
  - Non-Indigenous  ______  Unknown  ______
- English preferred language: ______  Yes  ______  No  ______
- Residential address:
  - Postcode:
- Home tel: ______  Work tel: ______  Email:
- Occupation:

Clinical Details:
- Admitted: ______  Discharged: ______
- Whether patient admitted to another medical facility within 30 days of this admission or discharge:
  - Yes  ______  No  ______  Unknown  ______

Did the patient have a temperature within the 30 days before this admission or discharge, or have any other procedure (eg, surgery) through which they may have been exposed to a possible infection with Ralstonia:
  - Yes  ______  No  ______  Unknown  ______

Name of medicator:

Appendix: Adapted Ralstonia case report form for multijurisdictional investigation into cases of Ralstonia bacteraemia 1 April to 26 June 2014

5.1-61
**Propofol Specific Questions:**

- **Was propofol administered?** [ ] Yes [ ] No [ ] Unknown
- **Why was propofol administered?** [ ] Unknown
- **How many times was propofol administered?** [ ] Unknown
- [ ] Inducer
- [ ] Other
- **What time and date?** [ ] Unknown
- **What was the start and finish times and date?** [ ] Unknown
- **Who administered the propofol?** [ ] Unknown
- **Who administered the propofol?** [ ] Unknown

*List all of the devices/vasa/bases and other equipment used in the process of administering propofol, syringes/drawing up needles, skin swabs, syringes/venflons.*

**Type** | **Brand/Other identifying information**
--- | ---

**How was the rubber stopper on the propofol distilled?**

**Clinical Procedures:**

- **List of clinical procedures performed in the month prior to collection of specimen:**
- [ ] Unknown
- **Type of procedure/surgery** | **Procedure date** | **Skin prep product** | **List of complex wounds and dressing used**
--- | --- | --- | ---

**Clinical Treatment and Outcomes:**

- **List of treatment administered for positive results of Pathogen:**
- **Name of medications/antibiotics** | **Dosage** | **Start date** | **Stop date**
--- | --- | --- | ---

**Complications:** [ ] Yes [ ] Specify

- [ ] Yes [ ] No [ ] Unknown
- **Outcome 14 days following initial isolation:**
- **Survived** | **Died** | **Date of death**
--- | --- | ---
- **Died directly due to Pathogen** [ ] Yes [ ] No [ ] Unknown
- **Date of death**
---
Appendix 9: List of expert panel members who participated in the Delphi rounds

1. Professor Bart Currie
2. Professor David Paterson
3. Associate professor Allen Cheng
4. Associate professor Ann Koehler
5. Dr Claire Heney
6. Dr Melissa McRae
7. Dr Barry Combs
### Appendix 10: DiversiLab® results, including association with propofol

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Alternate ID</th>
<th>Initials</th>
<th>Specimen</th>
<th>Received propofol</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>QLD-GC05975</td>
<td>TKA (Mar 2014)</td>
<td>Sputum</td>
<td>no</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>2</td>
<td>QLD-GC469685</td>
<td>BCT (Mar 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>3</td>
<td>QLD-GC108068</td>
<td>BL (Mar 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>4</td>
<td>QLD-RB1015828</td>
<td>CW (Mar 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>5</td>
<td>QLD-RB1015828</td>
<td>CW (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>6</td>
<td>QLD-RB1015828</td>
<td>CW (April 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>7</td>
<td>QLD-RB1015828</td>
<td>CW (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>8</td>
<td>QLD-RB1015828</td>
<td>CW (April 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>9</td>
<td>QLD-GC419685</td>
<td>CW (April 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>10</td>
<td>QLD-GC469685</td>
<td>CW (April 2014)</td>
<td>Sputum</td>
<td>NA</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>11</td>
<td>QLD-GC583328</td>
<td>CW (April 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>12</td>
<td>QLD-RB1015828</td>
<td>CW (April 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>13</td>
<td>QLD-GC583328</td>
<td>PW (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>14</td>
<td>QLD-GC583328</td>
<td>PR (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>15</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>16</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>17</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>18</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>19</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>20</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>21</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
<tr>
<td>22</td>
<td>QLD-GC583328</td>
<td>WA (May 2014)</td>
<td>Blood</td>
<td>yes</td>
<td>R. manitolytica</td>
</tr>
</tbody>
</table>

**Legend:**
- TA = tracheal aspirate
- QLD = Queensland
- SA = South Australia
- * = old isolates from storage
- Multiple isolates from the same patient are in coloured boxes

**Clone 1 Identity:** 94 - 98%

**Clone 2 Identity:** 93 - 99%

**Clone 3 Identity:** 97 - 99%

**Clone 4 Identity:** 97 - 99%

**Clone 5 Identity:** 97 - 99%

**Clone 6 Identity:** 50 - 58%
Appendix 11: Frequency of *Ralstonia* isolated from blood cultures, number of requests for blood culture and number that were positive, 2009 - 2014

<table>
<thead>
<tr>
<th>State</th>
<th>Years</th>
<th>Number of <em>Ralstonia</em> blood isolate</th>
<th>Number of blood requests (years)</th>
<th>Number of blood requests positive for bacteria (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>Jan 2013 – March 2014</td>
<td>0</td>
<td>34,801 in Financial year (FY) 2012-2013</td>
<td>3603 (FY 2012-2013)</td>
</tr>
<tr>
<td>NT</td>
<td>2013-2014</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>2012</td>
<td>1</td>
<td>18654</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>0</td>
<td>18026</td>
<td></td>
</tr>
<tr>
<td>TAS</td>
<td>2012</td>
<td>0</td>
<td>13604</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>0</td>
<td>15665</td>
<td></td>
</tr>
<tr>
<td>WA</td>
<td>2012 – 2014 (to date)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QLD</td>
<td>2011</td>
<td>1</td>
<td>139570</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>2</td>
<td>141154</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>3</td>
<td>141920</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014 (to date)</td>
<td>4</td>
<td>57810</td>
<td></td>
</tr>
<tr>
<td>NSW</td>
<td>1998</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>1</td>
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<td></td>
<td>2003</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2010-2014 (to date)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIC</td>
<td>2004-2013</td>
<td>5</td>
<td></td>
<td>6060 (average per year, 2004 - 2013)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NSW data from SWAPS, HAPS, ICPMR, SEALS, SYDPATH and PALMS
VIC data from VICNISS (healthcare associated infection surveillance system) and PHLN
SA data from PHLN and SA pathology
ACT data from TCH, CALVARY and NCPH
TAS data from RHH
WA data from PATHWEST
NT data from RDH
### Appendix 12: Results of microbiological testing of propofol solution, flip-off caps and external surfaces of the rubber stoppers

<table>
<thead>
<tr>
<th>Batch number</th>
<th>Laboratory</th>
<th>Test for Sterility (vials tested)</th>
<th>Test for Bacterial Endotoxins (vials tested)</th>
<th>Microbial Contamination Test - vial contents (vials tested)</th>
<th>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces</th>
<th>No. positive for bacterial growth/no. tested</th>
<th>Bacteria isolated</th>
</tr>
</thead>
<tbody>
<tr>
<td>A030906</td>
<td>A</td>
<td>Pass (20)</td>
<td>Pass (1)</td>
<td>Pass (3)</td>
<td>12/80</td>
<td>Bacillus species, Gram-positive cocci</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Pass (80)</td>
<td>Pass (4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-</td>
<td>-</td>
<td>Pass (12)</td>
<td>10/14 pools (6,7) (total 70 tested)</td>
<td>Bacillus species x 10 Coagulase-negative staphylococci x 3</td>
<td></td>
</tr>
<tr>
<td>A030907</td>
<td>A</td>
<td>Pass (20)</td>
<td>Pass (1)</td>
<td>Pass (3)</td>
<td>7/80</td>
<td>Bacillus species, Gram-positive cocci</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Pass (80)</td>
<td>Pass (4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-</td>
<td>-</td>
<td>Pass (10)</td>
<td>15/18 pools (6,7) (total 90 tested)</td>
<td>Bacillus species x 10 Coagulase-negative staphylococci x 5</td>
<td></td>
</tr>
<tr>
<td>Batch number</td>
<td>Laboratory(^1)</td>
<td>Test for Sterility(^2)(vials tested)</td>
<td>Test for Bacterial Endotoxins(^3) (vials tested)</td>
<td>Microbial Contamination Test(^4) - vial contents (vials tested)</td>
<td>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces(^5)</td>
<td>No. positive for bacterial growth/no. tested</td>
<td>Bacteria isolated</td>
</tr>
<tr>
<td>--------------</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>A031266</td>
<td>A</td>
<td>-</td>
<td>Pass (1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Ralstonia mannitolilytica(1 pool)(^6)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Pass (61)</td>
<td>Pass (4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>Pass (20)</td>
<td>Pass (1)</td>
<td>Pass (20)</td>
<td>0/20</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>A031267</td>
<td>A</td>
<td>-</td>
<td>Pass (1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Pass (61)</td>
<td>Pass (4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>Pass (20)</td>
<td>Pass (1)</td>
<td>Pass (20)</td>
<td>0/20</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>A040081</td>
<td>A</td>
<td>-</td>
<td>Pass (1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Batch number</td>
<td>Laboratory</td>
<td>Test for Sterility (vials tested)</td>
<td>Test for Bacterial Endotoxins (vials tested)</td>
<td>Microbial Contamination Test - vial contents (vials tested)</td>
<td>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>----------------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td></td>
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<tr>
<td>A031282</td>
<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
<td>-</td>
<td>0/20</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>Pass (20)</td>
<td>Pass (2)</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
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<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
<td>-</td>
<td>-</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>Pass (20)</td>
<td>Pass (2)</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A030021</td>
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<td>-</td>
<td>Pass (1)</td>
<td>-</td>
<td>-</td>
<td></td>
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<tr>
<td></td>
<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch number</td>
<td>Laboratory(^1)</td>
<td>Test for Sterility(^2)(vials tested)</td>
<td>Test for Bacterial Endotoxins(^3) (vials tested)</td>
<td>Microbial Contamination Test(^4) - vial contents (vials tested)</td>
<td>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces(^5)</td>
<td>No. positive for bacterial growth/no. tested</td>
<td>Bacteria isolated</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------</td>
<td>--------------------------------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>-------------------------------------------------</td>
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<td>------------------</td>
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<tr>
<td>A030146</td>
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<td>-</td>
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<td>-</td>
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<tr>
<td></td>
<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
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<td>-</td>
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</tr>
<tr>
<td>A030293</td>
<td>A</td>
<td>-</td>
<td>Pass (1) Pass (3)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A030872(^*)</td>
<td>B</td>
<td>Pass (60)</td>
<td>Pass (4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A030839(^*)</td>
<td>B</td>
<td>Pass (40)</td>
<td>Pass (4)</td>
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<td>-</td>
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</tr>
<tr>
<td>A030840(^*)</td>
<td>B</td>
<td>Pass (40)</td>
<td>Pass (4)</td>
<td>-</td>
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<td>A030932(^*)</td>
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<td>Pass (4)</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Batch number</td>
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<td>Test for Sterility (vials tested)</td>
<td>Test for Bacterial Endotoxins (vials tested)</td>
<td>Microbial Contamination Test - vial contents (vials tested)</td>
<td>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces</td>
<td></td>
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<td>No. positive for bacterial growth/no. tested</td>
<td>Bacteria isolated</td>
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<td>A031027</td>
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<tr>
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</tr>
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<td>Pass (60)</td>
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<td>A030288</td>
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<td>Pass (3)</td>
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</tr>
<tr>
<td>A031203</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>0/5</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch number</td>
<td>Laboratory&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Test for Sterility&lt;sup&gt;2&lt;/sup&gt;(vials tested)</td>
<td>Test for Bacterial Endotoxins&lt;sup&gt;3&lt;/sup&gt; (vials tested)</td>
<td>Microbial Contamination Test&lt;sup&gt;4&lt;/sup&gt; - vial contents (vials tested)</td>
<td>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces&lt;sup&gt;5&lt;/sup&gt;</td>
<td></td>
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<tr>
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<td>Pass (60)</td>
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<tr>
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</tr>
<tr>
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<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
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</tr>
<tr>
<td>A030085</td>
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<td>2/20</td>
<td>Bacillus species, Gram-positive cocci</td>
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<td>Pass (60)</td>
<td>Pass (3)</td>
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</tr>
<tr>
<td>A031195</td>
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<td>1/20</td>
<td>Bacillus species, Gram-positive cocci</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
<td>-</td>
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<tr>
<td>Batch number</td>
<td>Laboratory</td>
<td>Test for Sterility (vials tested)</td>
<td>Test for Bacterial Endotoxins (vials tested)</td>
<td>Microbial Contamination Test - vial contents (vials tested)</td>
<td>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces</td>
<td>No. positive for bacterial growth/no. tested</td>
<td>Bacteria isolated</td>
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<tr>
<td>A031196</td>
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<td>2/20</td>
<td><em>Bacillus species</em>, Gram-positive cocci</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Pass (60)</td>
<td>Pass (3)</td>
<td>-</td>
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<td><em>Bacillus species</em>, Gram-positive cocci</td>
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<tr>
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<td>Pass (3)</td>
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<td>4/20</td>
<td><em>Bacillus species</em>, Gram-positive cocci</td>
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<td>Pass (3)</td>
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</tr>
<tr>
<td>A020647</td>
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<td>0/2</td>
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<td>Batch number</td>
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<td>Test for Sterility(^2) (vials tested)</td>
<td>Test for Bacterial Endotoxins(^3) (vials tested)</td>
<td>Microbial Contamination Test(^4) - vial contents (vials tested)</td>
<td>Microbial Contamination Test - flip-off lid and rubber stopper external surfaces(^5)</td>
<td>No. positive for bacterial growth/no. tested</td>
<td>Bacteria isolated</td>
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<td>Gram-positive cocci</td>
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</tr>
<tr>
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<td>B</td>
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<td>Pass (3)</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
</tbody>
</table>

Notes

1. Laboratories
   A. TGA
   B. Manufacturer
   C. External laboratory\(^7\)
   D. External laboratory
   E. External laboratory

2. The Test for Sterility is a standard pharmacopoeial batch release test for an injectable medicine. A 'Pass' result means that no microbial contamination was detected in the portion of the samples that were tested. Each test uses 20 vials.

3. The Test for Bacterial Endotoxins is a standard pharmacopoeial batch release test for an injectable medicine. A 'Pass' result means that bacterial endotoxins were not detected in the portion of the samples that were tested.
4. The Microbial Contamination Test is not applicable to a sterile medicine. It was performed only as an adjunct test to estimate the level of microbial contamination should vial contents be contaminated. A 'Pass' result means that no microbial contamination was detected in the portion of the samples that were tested.

5. Flip-off lid and rubber stopper external surface swab tests were performed to assess bacterial contamination on these surfaces.

6. Testing was performed on pooled samples. Each pool contained the flip-off lids and swabs from the external surface of rubber stoppers from 5 vials.

7. Laboratory C has placed the following caveats on their test results:
   - The laboratory holds accreditation for testing of human diagnostic samples and for testing of clinical, non-human specimens for investigation of nosocomial infections in outbreaks and/or individuals, e.g. gastrointestinal endoscopes, vascular catheter tips and transfusion bags. The laboratory has limited accreditation for environmental testing.
   - Testing of the flip-off lids and external surface of the rubber stoppers included testing of the entire flip-off lid after disinfection of the outer surface of the lid with 70% alcohol. Aseptic techniques were used; however, removal of vial lids was difficult and adventitious contamination might have been introduced during the sampling and testing processes, e.g. the detection of coagulase-negative staphylococci in some pools. Isolation of Bacillus species from some pools might reflect lack of sporicidal activity of 70% alcohol used for disinfection of external surfaces of vial lids.
   - Test methods were adapted in-house. Test methods have not been fully validated and results should be interpreted accordingly.
   - Ralstonia manitoliytica was isolated from 1 of 32 pools. Ralstonia species are rarely recognised as contaminants in this laboratory.

8. These batches were not supplied to Australia or New Zealand.

9. Where a laboratory did not perform a test as part of the investigation the cell has a hyphen and is shaded.
### Appendix 13a: Simulated case-control study

<table>
<thead>
<tr>
<th>Number of cases with <em>Ralstonia</em> bacteraemia</th>
<th>Number in study base without <em>Ralstonia</em> bacteraemia</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received propofol</td>
<td>Did not receive propofol</td>
<td>Number eligible as controls (3/case)</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>0</td>
<td>80</td>
<td>24</td>
</tr>
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</tr>
</tbody>
</table>
## Appendix 13b: Simulated cohort study

<table>
<thead>
<tr>
<th>Number of cases with <em>Ralstonia</em> bacteraemia</th>
<th>Number in cohort without <em>Ralstonia</em> bacteraemia</th>
<th>OR=RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received propofol</td>
<td>Did not receive propofol</td>
<td>Total number in cohort</td>
</tr>
<tr>
<td>0</td>
<td>80</td>
<td>90</td>
</tr>
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<tr>
<td>1</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
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<td>25</td>
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<td>35</td>
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<td>25</td>
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### Appendix 14: Assessing the standard of evidence based on the Bradford Hill framework

<table>
<thead>
<tr>
<th>Standard of evidence suggested by Bradford Hill</th>
<th>Evidence for and against each standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength of association between exposure and outcome</strong></td>
<td>(we have stated ‘<em>Uncertain</em>’ where data are lacking or we lack appropriate technical knowledge)</td>
</tr>
<tr>
<td>For</td>
<td>All cases with <em>Ralstonia</em> bacteraemia received propofol (this could be restated as ‘risk of disease is zero if propofol was not administered’)</td>
</tr>
<tr>
<td></td>
<td>Six of the eight cases received a single brand of propofol, Provive, one received both Provive and the Sandoz product, and one received only the Sandoz product.</td>
</tr>
<tr>
<td><strong>Uncertain</strong></td>
<td>The strength of association refers typically to the value of the OR and/or RR. Based on the results of our simulations of a case control or case cohort study, we are unlikely to obtain a statistically significant result if we conducted a case control or case cohort study. This is because the study would have low power with only eight cases (or even with nine cases if we included the case from WA), the presence of multiple confounders (i.e. other opportunities to acquire the infection) and the potential multiple selection and measurement biases inherent in a retrospective study.</td>
</tr>
<tr>
<td></td>
<td>The strength of association with vials from specific propofol batch numbers is unknown. The exact batches administered are confirmed only for the patient at TPCH (Sandoz Propofol A031110 and A030504), while batch details for the other cases are either not known or could be narrowed down to two or four possible batches. In total, up to seven different batches may be implicated (as shown in the line list):</td>
</tr>
<tr>
<td></td>
<td>- three SA cases received either batch number A030906 or A030907</td>
</tr>
<tr>
<td></td>
<td>- three QLD cases received either batch number A031195, A031202, A031203, or A031210</td>
</tr>
<tr>
<td></td>
<td>- batch number for the VIC case is unknown</td>
</tr>
<tr>
<td></td>
<td>Propofol is frequently used in hospitals. Preliminary data suggest that more than 80,000 vials from the implicated batches were distributed across Australia before the quarantine date on 2 May 2014, and it has been difficult to determine the number already used. If we assume 50% have been used, then the risk of getting bacteraemia is eight episodes from 40,000 vials used.</td>
</tr>
<tr>
<td><strong>Consistency of our findings across</strong></td>
<td>For</td>
</tr>
<tr>
<td></td>
<td>Multistate nosocomial outbreaks of <em>Ralstonia</em> outbreaks have been reported from contamination of medical products (24, 26, 63-65).</td>
</tr>
</tbody>
</table>
### Different Populations

A multistate nosocomial outbreak as a result of intrinsic contamination of propofol have been reported in the literature (20, 25, 66). Multistate nosocomial outbreak caused by polyclonal (≥2 isolates) contamination of a medical product have been reported in the literature (20, 27, 28).

### Specificity in the Relationship between Exposure and Outcome

#### For

An isolate of *Ralstonia* from the lid of a vial of propofol (A030907) is genetically identical to clinical isolates from two patients managed at the two hospitals in SA (based on DiversiLab results). This result could not be replicated when vials from the same batch were retested at a later date. SA Pathology laboratory reported it “has NATA accreditation for human diagnostic work and sterility testing of bronchoscopes but does not hold extensive NATA environmental-testing accreditation. The methodology was specifically adapted in-house to test these propofol vials. The method has not been fully validated and results should be interpreted accordingly….. The technician attempted to use sterile technique but the removal of the vial lids was difficult. Contamination may have been introduced during sampling as evidenced by the mixture of cutaneous flora in the sub-cultures”.

#### Against

Strains of *Ralstonia* belong to five genetically different groups (three different groups of *R. mannitolilytica*, one of *R. Pickettii*, one of *R. insidiosa*) as shown in the updated DiversiLab results. None of the strains are found in more than one state.

- One cluster and one singleton in SA (*R. mannitolilytica* and *R. Pickettii* respectively)
- One cluster and one singleton in QLD (*R. mannitolilytica* and *R. insidiosa* respectively)
- A singleton in VIC (*R. mannitolilytica*)

The specificity of association by propofol batch number is uncertain. There are up to seven different batches implicated and it is not known which batch numbers were used in six cases. The cluster of cases with *R. mannitolilytica* in QLD isolated from blood cultures in cases who received propofol includes an isolate from a tracheal aspirate in a patient who did not receive propofol.

### Temporality, i.e. the Outcome Occurred after (and not before) Exposure

#### For

All cases received propofol between 1 hour and 23 days before developing clinical infection.

#### Uncertain

Some clinicians have expressed uncertainty about the interval acceptable to be defined as the incubation period. In two cases the incubation period was one and five hours respectively (both of whom were given propofol immediately before an endoscopy) and in two other cases, the incubation periods is 23 days. We need to clarify and define the incubation period to be used in our analysis.

### Biological Gradient, i.e. Dose-Effect Relationship between

#### For

The very short incubation periods of one and five hours have been interpreted as a dose-response relationship because patients being prepared for an endoscopy are given large bolus dose/s of propofol.
<table>
<thead>
<tr>
<th>exposure and outcome</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is a dose response relationship plausible if only the vial or the cap of the vial was contaminated but not the propofol solution? We do not have (would not be able to collect) validated data on the practice of drawing up the propofol and changing syringe needles before injecting patients. This information is also relevant to explain the mechanism of transmitting the infection when considering ‘biological plausibility’ (in the next row).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biological Plausibility of the association between</th>
<th>For</th>
</tr>
</thead>
<tbody>
<tr>
<td>The propofol solution and/or vial could have been contaminated if sterilisation procedures at the manufacturing facility were inadequate. The propofol packages and vials could have been contaminated during transport, distribution of supplies and in the process of drawing up and injecting the propofol solution. The propofol packages and vials could have been contaminated with multiple strains of <em>Ralstonia</em>.</td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td></td>
</tr>
<tr>
<td>Contamination with five genetically different strains of <em>Ralstonia</em>, but cases in each state having unique genotypes requires explanation.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coherence (“cause-effect relationship does not conflict with what is known of the natural history and biology of the disease”)</th>
<th>For</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyclonal <em>Ralstonia</em> contamination of medical solutions as well as of medical devices has been reported (20, 27, 28)</td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td></td>
</tr>
<tr>
<td>We have not yet found literature reports of contamination of a medical product with five different strains of the same bacteria, and where each state has a unique genotype</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experimental evidence “removing exposure” or lab-based experiments</th>
<th>For</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new cases were reported after the propofol was quarantined on 2 May. No new cases were reported among those who received propofol between the 27th of April and the date of quarantine on the 2nd of May (5 days).</td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td></td>
</tr>
<tr>
<td>This observation needs to be interpreted with caution; the last date propofol can be implicated was on 27 April: the patient from TPCH received only the Sandoz product and the isolate has a unique genotype compared with isolates from the other cases in QLD (TPCH has a specialist respiratory unit and a heart (?-lung) transplant unit). Could this case be classified as a possible ‘sporadic’ case infected from another case. If this is accepted as a possibility, then we could say that no further cases related to propofol were reported between 23 April and the day propofol was quarantined on 2 May, i.e. nine days.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analogy</th>
<th>For</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple strains of other bacteria contaminating medical solutions and devices have been reported.</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 15: Key points transcribed from each Panel Member’s response and facilitators’ conclusions on each question

<table>
<thead>
<tr>
<th>Question</th>
<th>Key points transcribed from each Panel Member’s responses</th>
<th>Facilitators’ conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q 1: excluded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q 2: If we assumed that propofol administration was causally associated with bacteraemia, can we conclude that pre-existing contamination of the propofol solution was unlikely and that the vial cap and/or rubber stoppers were more likely to have been the source of the Ralstonia?</td>
<td>“Yes” “This may be a reasonable conclusion”. For cases where onset was rapid, “explanations could include contamination of propofol solution in the syringe at the time of drawing up of propofol ....[and] internal contamination of these vials with Ralstonia prior to opening of the vials”. Response to question 5c included “[the laboratory results “do not generally support internal contamination of the product” “... it was more likely that the outside cap or on the top of the bung was contaminated.” “I think this is the most plausible explanation, but other sources are also possible. It is difficult to prove a negative, and it is possible but unlikely that contamination of a small proportion of the propofol may have occurred but has not been detected”. Response to question 5c included “The finding that the internal contents of propofol tested negative for bacterial growth and endotoxin is reassuring” “...it is possible that the Ralstonia was inside the bottle....it can survive under the cap....“We can come to any conclusions as to whether it was more likely to be in the bottle or under the cap as both are possible.” “...our understanding of Ralstonia species is limited. I would expect closer clonal similarities between cases if pre-existing contamination was the source.”</td>
<td>The vial cap and/or rubber stoppers rather than the propofol solution was the more likely source of the Ralstonia, but other sources of the bacteria cannot be excluded</td>
</tr>
<tr>
<td>Q 3: How confidently can we exclude other possible sources of exposure (apart from propofol administration) to Ralstonia in some or all the cases?</td>
<td>“Confident in the 2 SA mannitolilytica cases. Not confident in any of the others. But await WGS to make this even stronger link in SA” “In the case who had acupuncture, it is possible that this was the source of his bacteraemia, but without signs of local infection at the acupuncture sites, not highly likely. Generally infections secondary to acupuncture involve skin flora, though environmental organisms such as mycobacteria can also occur.”</td>
<td>Vial cap/rubber stopper was a likely source in the SA cases (if supported by WGS), but other sources of Ralstonia spp cannot be excluded for the other cases.</td>
</tr>
</tbody>
</table>
spreadsheet….. [SA case after endoscopy] has less other exposures which could be excluded.”

“I do not think that we have a smoking gun. I note that other, more common exposures have been associated with *Ralstonia* outbreaks….. Pseudo-outbreaks have also been associated with contaminated laboratory fluids”

“In view of the latest case at the RBWH with no propofol association, we can confidently say that there must be other sources for the bacteraemias. It has always been the case for the Gold Coast respiratory carriage patients that there must be other sources”

“Of patients receiving propfol, 99.9% will also receive a saline flush if not a N/Saline infusion and obviously an IV catheter.”

| Q 4: How likely is it that a patient with *Ralstonia* bacteraemia but without signs of a pulmonary infection may have transmitted *Ralstonia* to another patient as an explanation of why the same strain of *Ralstonia* was isolated from the sputum or tracheal aspirate of a patient who never received propofol? | “Very Unlikely”
| “This is quite possible – it’s usually due to cross infection in the wards when staff don’t ....follow r standard precautions”
| “It is more likely that both these patients were infected from as yet unknown common environmental source (not propofol)”
| “This usually suggests environmental contamination as a common source”
| “Highly unlikely”
| “Seems highly unlikely” |

Q 5a: How should we interpret the finding of the *Ralstonia* isolate from the vial cap, noting the caveat from SA Pathology?

“Await WGS but it is a very strong link given the Diversilab results and that we don’t culture *Ralstonia* commonly”

“... very likely that the isolation of *Ralstonia* from under a vial cap, and an isolate which was identical to one of the clinical isolates in SA, is significant, and not the result of laboratory contamination”

“...strongly suggests that vials of propofol were contaminated by *Ralstonia* on the outside by a unknown mechanism”

| Environmental contamination is the more likely source | Three members consider the isolation of *Ralstonia* from the vial cap to be significant, and one of them awaits confirmation with the results of the WGS. |
“We cannot say if the *Ralstonia* contaminated the vial cap and infected the patient from a common environmental source, or (less likely given the rarity of the organism) was a result of laboratory contamination. The significance of contamination of the external surface of the vial (as distinct to the vial contents) is uncertain”. Response to question 5b: “We have no control group of other vials”

“We do not have Diversilab patterns for commonly found *Ralstonia* isolates in SA so if there is lot of variation, then it is likely that these strains are causally related. If there is no variation (i.e. every single isolate of *Ralstonia* in SA is identical) then it is less likely / unlikely”. Response to Question 5c “One needs to read the SA caveat very carefully and note their methodology. Specimens were pooled and they state that it was difficult to get the lids off. If *Ralstonia* lives in the tap water and is an environmental contaminant, is it possible that this isolate was not actually from the vial?”

“Although the caveat does not fault the lab the reason we have NATA accreditation is to have confidence in the laboratory process when interpreting lab results in situations such as this”

<table>
<thead>
<tr>
<th>Q 5b: How should we interpret the TGA result of contamination of the internal surface of flip-off seal and rubber stopper with other bacteria?</th>
</tr>
</thead>
<tbody>
<tr>
<td>“It shows how commonly such contamination may well be present”</td>
</tr>
<tr>
<td>“…this is likely to represent microbial contamination of the exterior of the vials...... I would suggest that these batches have much heavier bacterial contamination than would be expected on such a product, and I think that the detection of so many cases of this unusual bacteraemia in patients who have received this product supports this”</td>
</tr>
<tr>
<td>“….the external surface of the propofol vials can be contaminated with environmental bacteria”</td>
</tr>
<tr>
<td>“We have no control group of other vials, but I would not expect the external surfaces of vials to be sterile, and the organisms isolated (moulds and bacillus particularly) are typical environmental organisms”</td>
</tr>
<tr>
<td>“This is an expected result. As the area under the vial lid is not expected to be sterile which is why it is cleaned. If cleaning protocols are not followed, then there may be many bacteraemias with bacillus spp. etc that are causally related to contaminants under the lid. These are difficult to detect but no doubt occur all the time. <em>Ralstonia</em> is so uncommon that we have picked this outbreak up”</td>
</tr>
<tr>
<td>Vial cap/rubber stopper were contaminated with environmental bacteria. Refer to literature review in Appendix 2: the plastic flip-off lid does not maintain sterility of the rubber stopper (Hilliard <em>et al</em> 2013; Buckley <em>et al</em>, 1994)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q 5c: How do these interpretations influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Support it, but it is the molecular typing that provides the “smoking gun”</td>
</tr>
<tr>
<td>Similar to our summary in 5a: two members support</td>
</tr>
<tr>
<td>Question</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Q6: Can we confidently implicate or exclude propofol administration as the cause of <em>Ralstonia</em> bacteraemia in some or all the cases?</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
**Q 7:** Noting the genetic similarity between the *R. mannitolilytica* isolate from the propofol vial cap and the clinical isolates from the two cases in different SA hospitals (RAH and SA Private), and the distinctive *R. Pickettii* isolate from the second patient in the same neurosurgical unit of the RAH, can we conclude that *Ralstonia* bacteraemia in all three cases was causally associated with the administration of propofol, and that the propofol/vial did not become contaminated in the respective clinical unit?

| “If WGS confirms all 3 clonal then not in clinical unit for those 2 *R. mannitolilytica* cases. *Pickettii* case less robust link and will remain only speculative but propofol a possible source for same reason as the other 2” |
| “Yes. It would be highly unlikely that there was any other explanation”. |
| “...unlikely that contamination of the external surface of the vials occurred at the respective clinical unit as the RAH and SA private patients have the same molecular type” |
| “No. The *Ralstonia Pickettii* is clearly different. The *Ralstonia mannitolilytica* isolates are related, but there is insufficient evidence that contamination of the propofol is implicated. However, it is possible that a very small proportion of propofol may be contaminated” |
| “One cannot be conclusive about the *R. Pickettii* patient but it is possible that the vials were contaminated with a range of *Ralstonia*. “One assumes all 3 associated either with propofol or perhaps a skin cleaning preparation for example”. |

**Q 8:** How confident can we be that the cases reported in QLD and/or VIC with diverse genetic strains were also causally associated with the administration of propofol because all of them had received propofol?

| “Less robust link and will remain only speculative but propofol a possible source for same reason as the 2 in SA. I.e. multiple contaminations of separate vials/batches etc.” |
| “No propofol, no bacteraemia. However I note the recent detection of contamination in water (drinking?) in Qld – these patients were not bacteraemic (as far as I know at this stage)” [Note updates described on page 1: two patients at the GCUH had bacteraemia and the source of infections at this hospital has been attributed to bottled water. One case at the RBWH who developed *Ralstonia* bacteraemia on 15 June had not receive propofol] |
| “No. They would have received multiple other potential exposures that have been previously associated with *Ralstonia* outbreaks, such as saline or heparin flushes” |
| “They may be associated but the source may not be the propofol, but water for injection, skin |

One member accepts propofol administration was source, three accept this explanation for the two cases with *R.m* (one of them accepts if this was confirmed with WGS).

Three members are uncertain about the source for the case with *R.p*. One member says there is insufficient evidence to implicate propofol, although this is possible.

Three members agree that it is unlikely that contamination occurred in the clinical unit.

The source of infection in the two bacteraemic cases at the GCUH, and possibly of the first case reported from the RBWH in May was unlikely to be propofol.

Source of the infection in the case from VIC is uncertain.
**Q.7** (should have been Q9): Based on the DiversiLab results and on the uncertainty of the batch number of propofol vials used in SA, VIC and QLD, what plausible hypotheses could we formulate on the likely site/s of contamination? More specifically, how likely is it that the propofol/vial may have been contaminated (a) at some stage before delivery to the clinical unit and (b) after arrival in the clinical unit?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is possible case in VIC was due to propofol contaminated from external surface of the vial but insufficient evidence to implicate propofol administration as the cause of the QLD. (Abstracted from response provided to question 5)</td>
</tr>
</tbody>
</table>

| One member considers contamination at the factory as “the only plausible explanation” and another member considers this acceptable if clonality can be confirmed with WGS. One member considers contamination occurred at some point before propofol was distributed to SA hospitals. Two other members are open-minded about the locality where the vial may have been contaminated. |

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**Q.8** (should have been Q10): What is the likelihood the propofol/vial was contaminated at the site of manufacture at Claris Life Sciences (India)?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Given the processes I’ve been told about re final cleaning of sealed vials with water sprays, it does seem most likely that this may well be responsible for contamination of the outside of already sealed vials before final packaging. Ralstonia is very much a water bug”</td>
</tr>
</tbody>
</table>

| One member considers this “highly likely” and another “most likely”. Three members say there is insufficient information to answer the question. One member considers |

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It is possible case in VIC was due to propofol contaminated from external surface of the vial but insufficient evidence to implicate propofol administration as the cause of the QLD. (Abstracted from response provided to question 5)”
Chapter 5.1

| distribution that are common to all vials. It is also possible that another exposure is implicated. I note there are no reports elsewhere in the world reported on ProMed, which might be expected following the Australian alert on a product presumably used in multiple countries” |
| “One cannot come to any conclusion about when / where the vials were contaminated….. Difficult to say unless the *Ralstonia* is isolated from inside the vial” |
| “If we assume the cases in different states are linked then that is the only plausible option. Alternatively, the one Victorian case is consistent with our estimated background rate but this appears different for other states” |

**The number of cases is indeed low considering the numbers of vials which have been used, however:**

- many clinicians may have followed appropriate procedures for disinfection of the rubber stopper
- many clinicians may have only drawn up propofol for procedures immediately prior to the procedure
- this organism is not highly pathogenic and bacteraemia would be more likely to be symptomatic in people who were immunosuppressed, as was the case for almost all of those cases detected
- many people with transient bacteraemia might not have presented for assessment or been investigated fully (i.e. blood cultures taken)
- not all vials may have been contaminated – this is quite likely – however it may be that those vials which were contaminated were quite heavily contaminated

We have not seen outbreaks of *Ralstonia* bacteraemia associated concurrently with the use of any other brand of propofol, or any other injectable medication, or commonly used devices, during this time period
### Appendix 16: List of the twelve questions and facilitators’ conclusions based on members responses in Round 2, members’ Round 3 comments on these conclusions and facilitators revised conclusions

<table>
<thead>
<tr>
<th>Question</th>
<th>Facilitators’ conclusions (included in Round 3)</th>
<th>Comments from each Panel Member to Facilitators’ conclusions</th>
<th>Facilitators’ revised conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q 1:</strong> What incubation period could be considered consistent with a causal association between propofol administration and bacteraemia?&quot;</td>
<td>Exclude responses to this question from further analysis because there are multiple potential confounders for the estimated incubation period in many cases; retain all eight cases as being potentially associated with propofol administration</td>
<td>No comments or objections to this conclusion from any member</td>
<td>Unchanged from original conclusion.</td>
</tr>
</tbody>
</table>
| **Q 2:** If we assumed that propofol administration was causally associated with bacteraemia, can we conclude that pre-existing contamination of the propofol solution was unlikely and that the vial cap and/or rubber stoppers were more likely to have been | The vial cap and/or rubber stoppers rather than the propofol solution was the more likely source of the *Ralstonia*, but other sources of the bacteria cannot be excluded | “But possibly only for the 2 SA cases”  
“Agree”  
“There is no requirement that the external surfaces of vials to be sterile”  
“Agree that the vial cap/rubber stoppers are the more likely source of the contamination for the majority of bacteraemia cases. Other sources of the bacteria cannot be excluded IN EVERY CASE, and notably in Qld there is a higher background rate which is no doubt climate-related.” In response to a comment by a fellow Panel Member about clonal similarities in pre-existing contamination, “If this was internal to the vial, agree. If external contamination would not necessarily expect clonal similarities.” | Unchanged from original conclusion, and confirmed with the responses in Table 2. |
Q 3: How confidently can we exclude other possible sources of exposure (apart from propofol administration) to *Ralstonia* in some or all the cases?

Vial cap/rubber stopper was a likely source in the SA cases (if supported by WGS), but other sources of *Ralstonia* spp. cannot be excluded for the other cases.

Added a qualifier to this statement by inserting “2 *R. manitotilytica*” before “SA cases”

Added a qualifier to this statement by inserting “as evidenced by the Diversilab results (if one assumes the lid isolate was real). I would however check the local bottled water supply to see if *Ralstonia* is isolated and then put the isolates through DiversiLab just in case!”

In response to the comment by the facilitators desiring support by WGS “Need to get over this fixation with WGS. It isn’t going to prove a thing. Environmental contamination = diversity. We started out with three species; how can anyone not understand that WGS will never prove that they are the same, because they aren’t.” In response to a statement by a fellow member that “we can confidently say that there must be other sources for the bacteraemias [in QLD]”, “Qld has always had a background rate of *Ralstonia* infection – this one case (RBWH with no propofol association) doesn’t disprove that there has been a problem with the propofol.” In response to a comment by a fellow Panel Member about respiratory carriage patients, “Most labs wouldn’t even work up these isolates – this could be occurring all over the country.” In response to a comment by a fellow Panel Member “Of patients receiving propofol, 99.9% will also receive a saline flush if not a N/Saline infusion and obviously an IV catheter”, this member said “The SA private hospital patient who developed bacteraemia within hours did not have a saline flush. His anaesthetist specifically stated this.”

Unchanged from original conclusion, except that one member has questioned the value of the WGS in either proving or disproving the association.

Q 4: How likely is it that a patient with *Ralstonia* bacteraemia but without signs of a pulmonary infection

Environmental contamination is the more likely source

No comment

“Agreed”

“Would add contamination of another source eg saline/water as a possible common source”

“and many laboratories would not bother to identify *Ralstonia* in respiratory...”

Environmental contamination or another common source such as saline/water is the more likely explanation.
may have transmitted *Ralstonia* to another patient as an explanation of why the same strain of *Ralstonia* was isolated from the sputum or tracheal aspirate of a patient who never received propofol? specimens as it is not considered a significant pathogen (exceptions such as cystic fibrosis patients).”

<table>
<thead>
<tr>
<th>Q 5a: How should we interpret the finding of the <em>Ralstonia</em> isolate from the vial cap, noting the caveat from SA Pathology?</th>
<th>Three members consider the isolation of <em>Ralstonia</em> from the vial cap to be significant, and one of them awaits confirmation with the results of the WGS. Members agree that isolation of <em>Ralstonia</em> from the propofol vial cap shows a likely link. However, one member stated this finding does not establish a causal link nor does it rule out other sources of the infection.</th>
</tr>
</thead>
</table>
| “R. spp. are very diverse and if WGS shows few differences in snps between the vial cap strain and the 2 clinical ones then they almost certainly are causally linked, even though the specific transmission mechanism remains speculative”
“*I think the diversilab results are sufficient to link the lid and patient isolates (if the lid isolate is not a contam).”*
“*I agree – probably significant finding but causal link cannot be established, particularly causal link to propofol cannot be established without establishing that *Ralstonia* isn’t found on other common sources eg saline*”
“Next question: If the result had been obtained by TGA, what would everyone be saying?” | “Agreed”
“agree”
“Agree” |

Q 5b: How should we interpret the TGA result of contamination of the internal surface of flip-off seal and rubber stopper with environmental bacteria. Refer to literature review in Appendix 2. Members agree that the vial cap/rubber stopper was contaminated with environmental bacteria, and that this is not unexpected.
| Q 5c: How do these interpretations influence your judgement of the hypothesis that propofol administration is causally associated with *Ralstonia* bacteraemia? | Similar to our summary in 5a: two members support the hypothesis, and one of them awaits confirmation with the results of the WGS. Three members appear not to be as convinced, and the sixth member did not respond to this question. | No comment  
"As 5a"  
“There is no “control” to implicate propofol specifically”  
In response to the comment “Support it, but it is the molecular typing that provides the ‘smoking gun’” made by a Panel Member says “strongly disagree – this would probably be true if it was internal contamination of the vials”  
Two members consider this an acceptable hypothesis (i.e. source of *Ralstonia* in the SA cases was the vial cap/rubber stopper; one member pointed out that as control vials were not used by the SA Pathology laboratory, a definitive conclusion is not possible. |
| --- | --- | --- |
| Q 6: Can we confidently implicate or exclude propofol administration as the cause of *Ralstonia* bacteraemia in some or all the cases? | (a) Two members suggest propofol administration is a likely cause for the cases in SA, and one of them awaits confirmation with the result of WGS. (b) One member suggests that contamination of the vial at the manufacturing site could explain the diverse genotypes - two genotypes in SA cases, and one genotype each in the | In response to (b): “yes is possible but will remain speculative in comparison to the matched SA cases/vial cap”  
“As in 5a, propofol is implicated if lid isolate is not a contaminant.”  
“Cannot be confident either way”  
No comment  
Unchanged from original conclusion. |
### Q 7: Noting the genetic similarity between the *R. mannitolilytica* isolate from the propofol vial cap and the clinical isolates from the two cases in different SA hospitals (RAH and SA Private), and the distinctive *R. Pickettii* isolate from the second patient in the same neurosurgical unit of the RAH, can we conclude that *Ralstonia* bacteraemia in all three cases was causally associated with the administration of propofol, and that the propofol/vial did not become contaminated in the respective clinical unit?

<table>
<thead>
<tr>
<th>Case</th>
<th>Source and Administration</th>
<th>Confidence</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>One member accepts propofol administration was source, three accept this explanation for the two cases with <em>R.m</em> (one of them accepts if this was confirmed with WGS). Three members are uncertain about the source for the case with <em>R.p</em>. One member says there is insufficient evidence to implicate propofol, although this is possible. Three members agree that it is unlikely that contamination occurred in the clinical unit.</td>
<td>No comment</td>
<td>“All answers seem to concur, the evidence for 2 cases is strong, but the likely cause of the <em>R. Pickettii</em> as well, and for all 3 more likely that contamination occurred related to the bottle not in the clinical units.” “Probable (not definite) cause for Rm cases, but certainly not for Rp case. Agree [with comment that contamination of the vial was unlikely to have occurred in the clinical unit]”</td>
<td>Unchanged from original conclusion.</td>
</tr>
</tbody>
</table>

### Q 8: How confident can we be that the source of infection in the two cases from TPCH and VIC?

<table>
<thead>
<tr>
<th>Source</th>
<th>Confidence</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>The source of infection in the two cases at the GCUH are related to the bottled</td>
<td>No comment</td>
<td>The cases at the GCUH are related to the bottled</td>
</tr>
</tbody>
</table>
| cases reported in QLD and/or VIC with diverse genetic strains were also causally associated with the administration of propofol because all of them had received propofol? | bacteremia cases at the GCUH, and possibly of the first case reported from the RBWH in May was unlikely to be propofol. Source of the infection in the case from VIC is uncertain. | “We now know that the QLD outbreak is in all likelihood related to the bottled water.”
“agree”
“The most recent cases associated with water are a different ‘outbreak’. Qld had cases at the RBH that were associated with propofol. The finding of sporadic cases that weren’t doesn’t mean that none of them were”

| Q 9: Based on the DiversiLab results and on the uncertainty of the batch number of propofol vials used in SA, VIC and QLD, what plausible hypotheses could we formulate on the likely site/s of contamination? More specifically, how likely is it that the propofol/vial may have been contaminated (a) at some stage before delivery to the clinical unit and (b) after arrival in the clinical unit? | One member considers contamination at the factory as “the only plausible explanation” and another member considers this acceptable if clonality can be confirmed with WGS. One member considers contamination occurred at some point before propofol was distributed to SA hospitals. Two other members are open-minded about the locality where the vial may have been contaminated. | No comment
“QLD cases are considered separately. Most likely that the contamination happened at time a) [before delivery to the clinical unit].”
“agree”
No comment

| water, and the likely link between the bottled water and the first case at the RBWH (isolate is also of the Cluster 2 genotype) is not yet known. The source of the other cases in QLD and VIC remain speculative. | Unchanged from original conclusion, except for the exclusion of the cases from GCUH that was attributed to the bottled water. |
| Q 10: What is the likelihood the propofol/vial was contaminated at the site of manufacture at Claris Life Sciences (India)? | One member considers this “highly likely” and another “most likely”. Three members say there is insufficient information to answer the question. One member considers this possible “if we assume the cases in different states are linked”. | No comment  
Insufficient info, unlikely.  
“there is insufficient information”  
In response to a comment by a Panel Member who commented on the lack of cases reported in other parts of the world “Perhaps this person needed to have heard TGA report on the amount of packaging that surrounds these vials, which might make them understand better that a multihospital, let alone multistate, outbreak of bacteraemias from this very rare pathogen is unlikely to have been due to contamination along the distribution trail” | One member accepted this as an explanation while two members said there was insufficient information, one of whom considered this to be “unlikely”. Two members did not comment in Round 3; however, in Round 2, one stated “insufficient information” while another responded “most likely”. |
### Appendix 17a: Panel Members’ assessment of the plausibility of the six hypotheses in the various clinical settings

#### Plausibility of hypotheses.

*Please select one of the following categories *:

"Almost Certain, Highly Likely, Likely/Probable, Unlikely, Almost Certainly Not"

<table>
<thead>
<tr>
<th>Hypothesis on source of <em>Ralstonia</em></th>
<th>Plausibility of hypotheses</th>
<th>Facilitators’ conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypothesis on source of <em>Ralstonia</em></strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two cases from SA with <em>R. mannitolilytica</em></td>
<td>Unlikely x2</td>
<td>Consensus: “Almost certainly not” or “unlikely”</td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x3</td>
<td></td>
</tr>
<tr>
<td>Case from SA with <em>R. Pickettii</em></td>
<td>Unlikely x2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x3</td>
<td></td>
</tr>
<tr>
<td>Case from VIC with <em>R. mannitolilytica</em></td>
<td>Unlikely x1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x4</td>
<td></td>
</tr>
<tr>
<td>Case from TPCH with <em>R. insidiosa</em></td>
<td>Unlikely x1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x4</td>
<td></td>
</tr>
<tr>
<td>Case from RBWH with <em>R. mannitolilytica</em></td>
<td>Unlikely x1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x4</td>
<td></td>
</tr>
<tr>
<td>Two cases from GCUH with <em>R. mannitolilytica</em></td>
<td>Unlikely x1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x4</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Facilitators’ conclusions</strong></td>
<td></td>
</tr>
<tr>
<td>1. Propofol solution contaminated at the manufacturing site</td>
<td></td>
<td>Consensus: “Almost certainly not” or “unlikely”</td>
</tr>
<tr>
<td></td>
<td>One [vial cap] possible, other [solution] unlikely</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unlikely x2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unlikely x2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Almost certainly not x3</td>
<td></td>
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<td>One member states this is “Almost certain” in all the settings except “Possible” for the case at the TPCH. For the two SA cases with <em>R.m</em>, one other member considers this “likely” but two other members consider this</td>
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</table>
5.1 - 95

| 4. Vial cap/rubber stopper contaminated after leaving manufacturing site but before stocked in the clinical unit | Likely/Probable x2 Possible still!! Almost certainly not x1 Insufficient information x1 | Likely/Probable x1 Possible still!! x1 Almost certainly not x2 Insufficient information x1 | Possible still!! x1 Almost certainly not x3 Insufficient information x1 | Almost certainly not x3 Insufficient information x1 | Likely/Probable x1 Almost certainly not x1 Insufficient information x1 | Likely/Probable x1 Almost certainly not x3 No response x1 | Likely/Probable x1 Almost certainly not x3 No response x1 | “unlikely” or “almost certainly not”. The fifth member states there is “insufficient information”.
For the Vic and QLD cases, three members state “Almost certainly not” or “unlikely”, while the fourth states “Insufficient information”.

| 5. Vial cap/rubber stopper contaminated in clinical unit due to poor aseptic techniques | Likely/Probable x2 Unlikely x2 Insufficient information x1 | Likely/Probable x1 Unlikely x1 Almost certainly not x1 Insufficient information x1 | Possible still!! x1 Almost certainly not x2 Insufficient information x1 | Unlikely x1 Almost certainly not x2 Insufficient information x1 | Likely/Probable x1 Unlikely x1 Almost certainly not x2 No response x1 | Likely/Probable x1 Unlikely x1 Almost certainly not x2 No response x1 | Likely/Probable x2 Unlikely x1 Almost certainly not x1 No response x1 | Three members agreed: “Almost certainly not” for the cases in QLD and VIC. Three members agree this is likely/possible for the SA cases with R. m. For the SA case with R. p, two consider this likely/possible, and two “Almost certainly not”.

| 6. Contamination was not on the propofol vial cap/rubber | Unlikely x3 Almost certainly not x1 Insufficient | Likely/Probable x1 Possible still!! x1 Almost certainly not x1 Unlikely x1 | Likely/Probable x1 Possible still!! x1 Almost certainly not x1 | Unlikely x1 Almost certainly not x3 | Likely/Probable x1 Almost certainly not x3 No response x1 | Likely/Probable x1 Almost certainly not x3 No response x1 | Likely/Probable x1 Almost certainly not x3 No response x1 | Four members agreed that this is “Almost certainly not” or “Unlikely” for the cases with R. m in SA, the GCUH |
| stopper, but in the clinical environment or injecting equipment in the clinical unit | information x1 | Almost certainly not x1 | Insufficient information x1 | Almost certainly not x2 | Insufficient information x1 | No response x1 | No response x1 | and RBWH, and two members state the same for the case from TPCH and VIC. Two members consider this to be “likely” or “possible” for the SA case with R.p and the case from VIC. |
Appendix 17b: Comments from Panel Members related to their responses in Table 1A.

<table>
<thead>
<tr>
<th>Hypothesis on source of <em>Ralstonia</em></th>
<th>Member’s comments related to their response to each hypothesis (only three respondents)</th>
</tr>
</thead>
</table>
| 1. Propofol solution contaminated at the manufacturing site | Expect more cases if a batch contamination of the fluid itself.  
Unlikely/almost certainly not. Without further evidence from VIC, it is impossible to comment and likewise tricky to draw a conclusion regarding the SA R. *Pickettii* case.  
Almost certainly not. |
| 2. Propofol solution and vial cap/rubber stopper contaminated at the manufacturing site | Expect more cases if a batch contamination of the fluid itself.  
Unlikely/almost certainly not.  
Almost certainly not. |
| 3. Only vial cap/rubber stopper contaminated at the manufacturing site | Possible still for Qld cases if not linked to the contaminated water and the typing of the water strain doesn’t match the case.  
Unlikely/almost certainly not.  
Almost certain. |
| 4. Vial cap/rubber stopper contaminated after leaving manufacturing site but before stocked in the clinical unit | Possible still for Qld cases if not linked to the contaminated water and the typing of the water strain doesn’t match the case.  
Plausible/worth considering.  
Almost certainly not. |
| 5. Vial cap/rubber stopper contaminated in clinical unit due to poor aseptic techniques | SA Rm cases unlikely - 2 separate clinical units – assuming clonality on WGS. Possible still for Qld cases if not linked to the contaminated water and the typing of the water strain doesn’t match the case.  
Plausible/Likely in SA.  
Unlikely. |
| 6. Contamination was not on the propofol vial cap/rubber stopper, but in the clinical environment or injecting equipment in the clinical unit | SA Rm cases unlikely - 2 separate clinical units – assuming clonality on WGS. Possible still for Qld cases if not linked to the contaminated water and the typing of the water strain doesn’t match the case.  
Plausible/worth considering.  
Almost certainly not. |
### Appendix 17c: Comments from Table 2A.

<table>
<thead>
<tr>
<th>Hypothesis on source of <em>Ralstonia</em></th>
<th>Member’s comments related to their categorisation of plausibility of each hypothesis</th>
<th>Facilitator’s comments – I think we could skip this as we have already commented in the last column of Table 2</th>
</tr>
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<tbody>
<tr>
<td>1. Propofol solution contaminated at the manufacturing site</td>
<td>Bart: Expect more cases if a batch contamination of the fluid itself Claire: Unlikely/almost certainly not. Without further evidence from VIC, it is impossible to comment and likewise tricky to draw a conclusion regarding the SA <em>Pickettii</em> case Ann: Almost certainly not</td>
<td>The three members who left comments all agree this is unlikely</td>
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<tr>
<td>2. Propofol solution and vial cap/rubber stopper contaminated at the manufacturing site</td>
<td>Bart: Expect more cases if a batch contamination of the fluid itself Claire: Unlikely/almost certainly not. Ann: Almost certainly not</td>
<td>The three members who left comments all agree this is unlikely</td>
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<tr>
<td>3. Only vial cap/rubber stopper contaminated at the manufacturing site</td>
<td>Bart: Possible still for QLD cases if not linked to the contaminated water and the typing of the water strain doesn’t match the case Claire: Unlikely/almost certainly not. Ann: Almost certain</td>
<td>Assuming QLD cases are not related to propofol, two members agree this is unlikely, one member says this is almost certain</td>
</tr>
<tr>
<td>4. Vial cap/rubber stopper contaminated after leaving</td>
<td>Bart: Possible still for QLD cases if not linked to the contaminated water and the typing of the water strain doesn’t match the case Claire: Plausible/worth considering Ann: Almost certainly not</td>
<td>Assuming QLD cases are not related to propofol, two members agree this is unlikely, one member says this is plausible</td>
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<td>5. Vial cap/rubber stopper contaminated in clinical unit due to poor aseptic techniques</td>
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<td>Bart: 1. SA Rm cases unlikely - 2 separate clinical units – assuming clonality on WGS</td>
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<td>2. Possible still for Qld cases if not linked to the contaminated water and the typing</td>
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<td>Claire: Plausible/Likely in SA</td>
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<td>Ann: unlikely</td>
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<td>Assuming QLD cases are not related to propofol,</td>
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<td>two members agree that this is unlikely, while</td>
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<td>one member says this is plausible in SA</td>
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<table>
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<tr>
<th>6. Contamination was not on the propofol vial cap/rubber stopper, but in the clinical environment or injecting equipment in the clinical unit</th>
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<tbody>
<tr>
<td>Bart: 1. SA Rm cases unlikely - 2 separate clinical units – assuming clonality on WGS</td>
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<td>2. Possible still for Qld cases if not linked to the contaminated water and the typing</td>
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<td>of the water strain doesn’t match the case</td>
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<td>Claire: Plausible/worth considering</td>
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<td>Ann: Almost certainly not</td>
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<tr>
<td>Assuming QLD cases are not related to propofol,</td>
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<td>two members agree that this is unlikely, while</td>
</tr>
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<td>one member says this is plausible in SA</td>
</tr>
</tbody>
</table>

**Summary**
References

Chapter 5.2 - The Ebola Virus Disease Outbreak in West Africa
Experiences from the field in Sierra Leone, May - July 2015

‘The Ebola epidemic ravaging parts of West Africa is the most severe acute public health emergency seen in modern times. Never before in recorded history has a biosafety level four pathogen infected so many people so quickly, over such a broad geographical area, for so long’ (1).

*MAE course requirement:* Outbreak Investigation
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Preface

This chapter describes my experiences working with the World Health Organization (WHO) supporting their response to the Ebola Virus Disease (EVD) outbreak in Sierra Leone in West Africa, 2014 - 2015. On 8 December 2014, the coordinator of the Master of Philosophy in Applied Epidemiology (MAE) program, Martyn Kirk, sent an email to the MAE2014 cohort informing us that there was an ongoing need for field epidemiologists to assist with the response to the EVD outbreak in West Africa. Martyn advised that if we were interested in assisting with the response, and if we had the support of our field placement supervisors, that they would support our deployments through the WHO Global Outbreak Alert and Response Network (GOARN). As soon as I read this email I put my hand up. I spoke with my field and academic supervisors and all were in support. Although, I initially didn’t get short listed through GOARN, I was among one of the nominees later put forward by Martyn Kirk to undergo pre-deployment training with the WHO Western Pacific Region Office (WPRO) as part of their response. A few months later, on 14 April 2014, I received an email from WPRO advising me that they were initiating the process for my deployment to support their response to the EVD outbreak in West Africa. After a detailed medical check, nine vaccinations, three online training courses and many signed forms later, on 21 May 2015 I was off to Sierra Leone, assigned to the Port Loko district.

I have felt very privileged to be able to contribute to and support WPRO on the ground in their response to the EVD outbreak in Sierra Leone. My time in Sierra Leone working as a trainee field epidemiologist was life changing and further cemented in me that this is exactly the kind of work I want to do.

This chapter describes my role and general responsibilities in the outbreak, the structure of the investigation teams and also provides a detailed description of a cluster investigation that I was involved with. Within this cluster, I led the investigations in three out of the six villages it affected. In Appendix 1 I provide the PowerPoint slides from a presentation that I made to the Indigenous Health Divisional forum (my field placement) describing my experiences working on this outbreak.
Investigatory role

I spent ten weeks (21 May to 28 July 2015) in Port Loko district. Port Loko district is one of ten districts in Sierra Leone and is the fourth most populous district for all of Sierra Leone. It is a mostly rural area and its major activities are mining and farming (2). Specific tasks of my mission outlined in the Terms of Reference were (under the guidance of the field coordinator):

1. to provide technical support to the function of surveillance and epidemiology;
2. to support surveillance activities in affected and neighbouring districts, especially in terms of active case finding and contact tracing;
3. to assist in outbreak response, especially in field investigation;
4. to contribute to the training of health personnel and community sensitisation;
5. to prepare regular information products including daily situation reports on the evolution of the outbreak, ongoing and planned activities; and
6. to undertake other duties that the field coordinator may assign.

The majority of my time was spent in the field conducting field investigations, supporting surveillance activities in Port Loko district by conducting active case finding and contact tracing, while responding to the needs of people under quarantine. With the support and guidance from the field coordinator and the overall lead epidemiologist for Port Loko district, I was the epidemiological lead for three outbreak investigations in three villages and one investigation into a secret burial. These cluster outbreaks and secret burials affected eight villages spanning four chiefdoms of Port Loko district. As the epidemiological lead, my role included:

- Overall management of the outbreak response teams (break down of field epidemiological teams is shown in Figure 1).
- Conducting interviews to identify contacts to be line listed and quarantined (with the team).
- Conducting risk assessment of contacts based on exposure to the cases, to separate high risk contacts from low risk contacts in quarantine homes (with the team). Anyone considered a contact (high and low risk) went into quarantine. High risk contacts were quarantined in separate homes to those who were low risk.
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- Taking a census of affected villages so the people who were not put into quarantine could also be monitored (with the team). This also required entering the census data into Excel and creating monitoring sheets for contact tracers.
- Working with surveillance teams to identify the location of missing contacts and arrange for them to be placed into quarantine if found.
- Liaising with partners (The Department for International Development, OXFAM, Plan, World Food Programme, The United Nations Children’s Fund) to ensure quarantine homes had adequate access to toilets, food, water, washing and sanitary materials, and mosquito nets, as well as people to look after the farms for the farmers under quarantine.
- Ongoing monitoring and supervision of quarantine homes, particularly homes with high risk contacts to ensure these homes were being visited twice daily by: contact tracers, social mobilisation teams, psychosocial teams and to identify any other concerns from the quarantine homes and pass on any concerns to relevant organisations.
- Preparing investigation reports and regular updates for the WHO epidemiological lead and field coordinator.

**Figure 1:** Break down of outbreak investigation teams and organisations in Port Loko, Sierra Leone in 2015

*DHMT - District Health Management Team, WHO - World Health Organization, CDC - The Centers for Disease Control and Prevention, UNFPA – United Nations Population Fund*
In addition to these investigations, I also worked with international partner organisations including GOAL, The US Centers for Disease Control and Prevention (CDC) and local Sierra Leonean department of health staff from the District Health Management Team (DHMT) on ‘silent section’ surveillance plans, and provided technical support in the field to surveillance officers when they were conducting the silent section assessments. The purpose of the silent section surveillance assessments was to identify communities that were not reporting illnesses to the District Emergency Response Committee ([DERC] a committee comprising all local and international organisations present on the ground in Port Loko district responding to the outbreak), so that surveillance systems in these communities could be strengthened.

It was also a requirement for WHO field epidemiologists to attend the following daily meetings if there was nothing urgent to attend to in the field.

1. 7.30am: DHMT surveillance officer meeting to plan the day’s activities, assess needs and provide support.
2. 8.30am: epidemiology technical meeting with WHO, The CDC, DHMT, and GOAL to set epidemiological/surveillance priorities for the day and discuss challenges.
3. 5.00pm: ‘After Action Review’ meetings with surveillance officers, to review the day’s activities, agree on the next day’s activities and to address data quality issues from field surveys.
4. 6.00pm: meeting with the DERC.
5. 7.00pm: WHO internal meeting.
Lessons learnt

I learnt many lessons through working on this outbreak. One of the biggest lessons I learnt is how important community engagement is to controlling a disease. You can have a good understanding of how to control a disease – you can understand everything about a disease from the biological, medical, and epidemiological perspectives, but if you don’t understand the people and have a way of communicating to the people in a way that speaks to them, and have interventions that are culturally appropriate - the biomedical knowledge of how to control a disease becomes less useful.

I learnt how damaging mistrust and misperceptions can be in this setting. There were people we could not help because they didn’t trust or believe that we could help them, so instead of seeking help they ran away, unintentionally spreading the disease further. In this setting it can be very difficult to get truthful answers from people regarding their level contact with a case, or another person’s level of contact with a case for fear of going into quarantine, or for fear of being punished for looking after sick people and not reporting them.

While there was still an element of chaos, so much seemed to work well e.g. good vehicle transport, internet (was still a bit intermittent, especially when it rained, but it was still much better than I was expecting) and daily reports from the laboratory so we had access to sample results within 24 hours (sometimes sooner if requested). I could see and benefited from the hard work of the many people who had been on the ground before me, who worked hard to put reporting and logistical mechanisms and systems in place.

I also learnt that an outbreak of this scale has devastating effects on other diseases too. The whole country and health response was focused on controlling one deadly disease but other diseases didn’t stop; in fact the under-five child mortality rate had increased as a result of this outbreak. Mothers were too scared to take their children to be vaccinated for fear of being sent to an ETU, so vaccine-preventable diseases increased. There was a measles outbreak happening at the same time while I was there and little
attention (that I could see) could be paid to that. The health system was completely over-stretched.

**Public health impact**

No secondary transmission occurred in two of the three village cluster investigations or from the secret burial cluster that we worked on. Even though much of the international community was slow to respond to this outbreak overall, the multinational response efforts have helped control the outbreak. This response has also led to building up the skills for many of the local outbreak responders and to rebuilding Sierra Leone’s health system. Sierra Leone currently (December 2015) remains EVD transmission free, but many organisations like WHO remain while the country maintains heightened surveillance and continues to strengthen the surveillance system, and to ensure the country is prepared to respond should there be a re-emergence (3). In addition to this, they are now starting to focus on addressing other public health issues, such as the very high rates of maternal and child deaths.

I shared my experience working in Sierra Leone with the Indigenous Health Division (my field placement) through a presentation. In this presentation I provided a brief summary of EVD, how it is transmitted, a summary of the EVD outbreak in West Africa, how I got involved and I briefly described the cluster investigation I supported. Through this presentation I shared with colleagues the challenges this outbreak response faced, highlighting the importance of community engagement. This is something that is not only important in this outbreak setting but also core to Aboriginal and Torres Strait Islander public health. We discussed that we face similar challenges here in Aboriginal and Torres Strait Islander health – the importance of cultural traditions, fear, misperceptions and lack of trust. Community engagement is integral to the success of any Aboriginal and Torres Strait Islander project or health program.
Acknowledgements

I would firstly like to thank Martyn Kirk for putting my name forward for pre-deployment training with WHO WPRO. I would also like to say thank you to all of my academic and field supervisors: Rachel Meyer, Hope Peisley, Masha Somi, Emily Fearnley and Mahomed Patel for supporting and guiding me through various stages of the deployment. From the initial application process to the Global Outbreak and Response Network (GOARN), to practical guidance on how to be prepared for the field e.g. ‘be flexible and patient – things go wrong and a lot happens at the last minute, luggage is lost regularly (and it did get lost - for two weeks) so pack enough clothes and essentials in your carry on’ and to what to pack (a bag full of muesli bars and multivitamins). I greatly appreciate the support and encouragement I received from all of my supervisors. I would also like to thank WHO WPRO for giving me the opportunity to be part of their response - for their training and excellent support on the ground. The WHO WPRO team really looked after their people on the ground. I would like to thank my Sierra Leonean colleagues – ‘we are all in this together’. Last but far from least, I would like to thank my wonderful family for cheering me on every day I was there in spite of the stress me being there caused them.
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Abbreviations

CDC  The Centers for Disease Control and Prevention
DERC  District Emergency Response Committee
DHMT  District Health Management Team
ETU  Ebola treatment unit
EVD  Ebola Virus Disease
GOARN  Global Outbreak Alert and Response Network
UNICEF  The United Nations Children’s Fund
WHO  The World Health Organization
WPRO  World Health Organization Regional Office for the Western Pacific
Abstract

Background
On 21 May 2015, I was deployed to provide epidemiological support to the response to the Ebola Virus Disease (EVD) outbreak in Sierra Leone. This chapter describes a cluster investigation I was involved with. The aims of this investigation were to:

1. Identify contacts of an index case.
2. Quarantine high and low risk contacts in separate high and low risk quarantine homes.
3. Monitor contacts for 21 days from their last date of contact with the case and to send them to Ebola Treatment Units (ETU) if they developed any EVD symptoms.
4. Send symptomatic contacts meeting the suspected case definition to an ETU.
5. Locate missing contacts.
6. Identify the source of infection for cases.

Methods
To identify contacts and source of the cases, we interviewed family and community members. High and low risk contacts were quarantined separately. Contract tracers visited the contacts at least twice a day. If contacts showed any signs of EVD, they were sent to an ETU for treatment and testing. Cases in the cluster were summarised by age, gender, onset, outcome and risk factor. A disease transmission tree was developed to describe links between cases and the timeline of events.

Results
This transmission chain was triggered by a missing contact from another cluster. This transmission chain lasted three months, spanned six villages and two districts. There were 13 confirmed cases of EVD and two suspected cases. Of these 87% (n = 13) died. Seventy-three percent of cases (n = 11) were female. The median age of cases was 28 years (range: 11 days to 65 years). The date of onset ranged from 26 April 2015 to 10 July 2015. Of those who died, seven died in the community and six died in the ETU. A total of 294 contacts were identified. Of these, 73 were classified as high risk. Sixteen high risk contacts ran away before they could be quarantined. Of these, five were found and quarantined, four were found and taken to an ETU, one was found dead in the community and another was found dead in the community after giving birth, and five
were never found. The risk factors identified for developing EVD in this cluster investigation were: washing and burying the dead body of an EVD case (53%, n = 8), sleeping in the same room or having close living contact with an EVD case (13%, n = 2), caring for a symptomatic EVD case (7%, n = 1), assisting with the delivery of an infant born from an EVD mother (13%, n = 2), and being born to an EVD case (7%, n = 1) or exposure to EVD positive breast milk (7%, n = 1).

**Conclusion**

This investigation shows the impact a missing contact can have in this outbreak setting and how essential it is to have a complete and accurate contact list to prevent disease transmission. This cluster was driven by challenges that have persisted throughout this outbreak: fear, mistrust of response efforts, limited understanding of EVD, community misperceptions and a stronghold on cultural traditions. A stronger emphasis on community engagement might have reduced the risk of disease for some of the cases in this cluster.
Background

**Ebola virus**

Ebola Virus Disease (EVD) is a zoonotic disease caused by a virus of the family Filoviridae, genus *Ebolavirus* (4). It was first discovered in 1976 near the Ebola River in the Democratic Republic of Congo (5). Since then, sporadic outbreaks have been described in several other African countries (6), and some Western countries (Figure 2). There are five known strains of Ebola, of which four (one to four listed below) are known to cause disease in humans:

2. Sudan virus (*Sudan ebolavirus* - SEBOV) (7).
3. Taï Forest virus (Taï Forest ebolavirus, formerly *Côte d’Ivoire ebolavirus* - CIEBOV) (8).
5. Reston virus (*Reston ebolavirus* - REBOV) - causes disease in non-human primates, but not reported in humans (10).

![Figure 2: Locations of Ebolavirus disease (EVD) outbreaks in humans and infections in animals](image)

(A) Regions of Africa that have previously reported outbreaks of EVD caused by ZEBOV, SEBOV, and BEBOV. The Taï Forest region in Côte d’Ivoire was the only region of West Africa to report a case of EVD caused by CIEBOV prior to the 2013-2015 outbreak. (B) REBOV has been introduced into the USA several times between 1989 to 1996 via imported macaques and into Italy in 1992 (C). (D) REBOV was imported into the Philippines also via imported primates and has also been detected in pigs on two farms in the Philippines (11).
**The disease**

Infection with Ebola virus causes an acute viral syndrome in human and non-human primates (monkeys, gorillas, chimpanzees) and possibly other mammalian species (11). The disease, EVD, is characterised typically by three phases:

- **Phase 1:** non-specific fever, headache, and myalgia.
- **Phase 2:** gastrointestinal phase (which usually includes diarrhoea and vomiting).
- **Phase 3:** neurological manifestations and bleeding (12).

The case fatality rate varies depending on the strain of the Ebola virus, the route of entry of the virus, the age of the patient and where the patient is being treated (11, 12). ZEBOV species are reported to be the most deadly species, with a case fatality rate ranging from 60% to 90%, followed by the SEBOV virus which has a case fatality ranging from 40% to 60%. For the one Bundibugyo virus outbreak that has occurred, the case fatality rate was 25% and the one person infected with Taï Forest virus survived (11).

**The reservoir**

Bats are believed to be the natural reservoir for Ebola virus (13). While a range of other hosts including rodents (14), arthropods and even plants have also been suggested as potential reservoirs (15).

**Transmission**

Humans become infected with Ebola virus via contact with infected body fluids such as blood, urine, saliva, sweat, faeces, vomit, breast milk and semen. The virus requires entry into the body through mucosal surfaces or breaks in the skin (11). Outbreaks of EVD among humans are believed to be triggered by the introduction of the disease into the human population from the animal reservoir (16) and the outbreak is sustained through person to person transmission (Figure 3).
Figure 3: Ebola virus transmission cycle (17)


On 23 March 2014, the WHO was notified by the Ministry of Health of Guinea of an outbreak of EVD in Guinea (18). The epidemic spread rapidly from Guinea (19) to the bordering countries of Sierra Leone and Liberia. The outbreak reached a further seven countries [Italy (20), Mali (21), Nigeria (22), Senegal (23), Spain (24), the United Kingdom (25), and the United States of America (26)] through infected healthcare workers. The last of these cases was an Italian health care worker who developed symptoms after returning home to Italy on 10 May 2015 [reported to WHO on 12 May 2015 (20)]. On 8 August 2014, the WHO declared the outbreak as a public health emergency of international concern (PHEIC) (27). A PHEIC is an extraordinary event that poses risk to the international community and may require an international coordinated response by member states of the International Health Regulations (2005) (IHR). The decision to declare a PHEIC currently sits with the WHO Director-General and requires the convening of the IHR Emergency Committee. The IHR committee advises the WHO Director-General on health measures to be implemented to prevent or reduce international spread (28).
As of 29 November 2015, the WHO has reported a total of 28,637 clinically compatible cases of EVD acquired in West Africa, or related to the West African outbreak. Of these, 11,306 people have died (29). Liberia, Guinea and Sierra Leone have had the majority of cases (Figure 4) (30).

Figure 4: As of 29 November 2015, total number of EVD cases and deaths linked to West Africa outbreak (31)
WHO stated that ‘The Ebola epidemic ravaging parts of West Africa is the most severe acute public health emergency seen in modern times. Never before in recorded history has a biosafety level four pathogen infected so many people so quickly, over such a broad geographical area, for so long’ (1). After an initial delay, a multinational group including Ministries of Health, The Centers for Disease Control and Prevention (CDC), the WHO, OXFAM (Oxford Committee for Famine and Relief), GOAL, The United Nations Children’s Fund (UNICEF), Red Cross\(^1\) and other partners have been working hard to reduce transmission and bring the outbreak to an end in West Africa (32).

Case numbers have dropped dramatically since early 2015, and Liberia, Italy, Mali, Nigeria, Senegal and Spain, the United Kingdom and Sierra Leone have all since been declared EVD transmission free (33-39). As of 29 November 2015 the last case in Guinea tested negative for the second time on 16 November 2015, and if there are no further cases, Guinea could be declared EVD transmission free on 28 December 2015. On 20 November 2015, three EVD cases were reported in Liberia (40) after the country was declared EVD transmission free for the second time on 3 September 2015 (37).

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\(^1\) Role of partner organisations in Sierra Leone:
- **WHO** took the lead with coordinating the response in Port Loko district while focusing on surveillance and epidemiology, infection prevention control, information and communications and logistics.
- **CDC** provided assistance with surveillance, contact tracing, data management, and laboratory testing and health education. They also provided logistics, staffing, communication, analytics, management and other support functions for the response.
- **OXFAM** focused on community health and water, sanitation and hygiene programs.
- **GOAL** supported social mobilisation and surveillance activities as well as assisted with the running of an Ebola treatment unit, and training security personnel in infection control.
- **UNICEF** focused on care for children, social mobilisation, building community care centres, and community support for survivors, and was a provider of supplies (protective gloves, safety goggles, intravenous fluids, medicines, soap and chlorine).
- **Red Cross** focused on raising awareness in the communities about EVD and on prevention messages, as well as contact tracing and providing psychosocial support.
Introduction to Sierra Leone

Sierra Leone is a country located in West Africa. It borders Guinea to the north-east, Liberia to the south-east and the Atlantic Ocean to the south-west (Figure 5) (41). Despite being a mineral and agriculturally rich country, 60% of the population live on less than US$1.25 a day (42). It ranks 180 out of 187 on the Human Development Index in 2011. Approximately, 42% of the population are under the age of 15 years and the estimated life expectancy at birth is 57.7 years. Forty-one percent are literate and 70% are unemployed or underemployed (42). The major economic activities for the country is farming and mining (41). Prior to the EVD outbreak, Sierra Leone had a ratio of approximately one to two doctors per 100,000 people. The same ratio was also reported for Guinea and Liberia (43).

![Figure 5: Sierra Leone borders Guinea to the north-east, Liberia to the south-east and the Atlantic Ocean to the south-west in West Africa (44)](image)

As of 2014, Sierra Leone has a population of approximately 6,315,627 (45) and is made up of 16 ethnic groups. The two largest ethnic groups are the Temne and the Mende People (41). Sierra Leone’s official language is English but Krio is the most widely spoken language throughout the country, and is a shared language that unites the 16 ethnic groups (42).
Geographically, Sierra Leone is broken down into four regions: Northern Province, Eastern Province, Southern Province and the Western area. These four regions are further broken down into 14 districts (Figure 6), 149 chiefdoms and then villages (46). The capital of Sierra Leone is Freetown and is located in the Western area region (41).

Figure 6: The 14 districts of Sierra Leone (47)

Port Loko district
Port Loko is a district located in Northern Province. It is made up of 11 chiefdoms (46) and has an estimated population of 500,992 (48). It is the most populous district in the Northern Province and is the fourth most populous district for all of Sierra Leone. The district’s major economic activities are mining and farming (mainly rice, cassava, and sweet potato) (2). The largest ethnic group in Port Loko is the Temne people (48). After Freetown, Port Loko has had the largest cumulative number of EVD cases to date (49).
Cluster X investigation in Port Loko district, Sierra Leone 2015

Scenario
A 45 year old female (index case) attended the secret burials of relatives in Kambia district (borders to the north of Port Loko district) around 17 April 2015. She is estimated to have developed symptoms of EVD on 26 April 2015. On 27 April 2015 (while symptomatic), she travelled from Kambia district to Village 1 in Port Loko district where she died from EVD on 2 May 2015. From this case, 113 contacts were quarantined in Village 1. A grandson (ten year old male) of the index case (missed on the contact list), developed EVD symptoms on 3 May 2015 and was sent to a traditional healer in Kambia district for treatment. After his condition did not improve, he was collected by his other grandmother to be cared for at home by family. He was taken back to a house where eleven of his relatives lived in Village 2.

This missing contact triggered a transmission chain that we did not become alerted to until this child’s grandfather sought treatment from the local Primary Health Unit (PHU) on 6 June 2015. This is when our investigations began.

This section describes the investigations and control measures undertaken by the investigation teams comprising staff from WHO, CDC and District Health Management Team (DHMT), originating from a missed contact (ten year old male described above) who became a case. I was the epidemiological lead for the investigations conducted in three of the six villages involved in this cluster.

Objectives
1. To identify contacts of the index case.
2. To quarantine high and low risk contacts in separate high and low risk quarantine homes.
3. To monitor contacts for 21 days from their last date of contact with a case and to send them to Ebola Treatment Units (ETU) if they developed EVD symptoms.
4. To send symptomatic contacts meeting the suspected case definition to an ETU.
5. To locate missing contacts.
6. To identify the source of infection for cases.

Methods
To identify contacts and source of the cases, we interviewed family members, neighbours, community members, section chiefs - anybody we thought could be
possible contacts, or who would provide us with information regarding contacts. These were unstructured interviews and we conducted the interviews with the chiefdom surveillance officers. These surveillance officers knew the communities and translated for us. This also led to building up the epidemiological investigation skills of the chiefdom surveillance officers.

Once contacts were identified we classified them as high or low risk depending on their level of contact with the case. Level of contact was categorised as follows:

1. Touched the bodily fluids of the case (high risk).
2. Direct physical contact with the body of the case (live/dead) (high risk).
3. Touched or shared linens, clothes or dishes, eating utensils of the case (lower risk).
4. Slept, ate, or spent time in the same household or room as the case (lower risk).

Anyone considered a contact (high and low risk) went into quarantine. High risk contacts were quarantined in separate homes to those who were low risk. Both high and low risk contacts in quarantine were monitored by contact tracers. Contact tracers visited the contacts at least twice a day. They would take the temperature of the contact and record any symptoms. Both high and low risk contacts in quarantine were immediately removed and taken to an ETU for testing if they showed any sign of EVD illness.

People in quarantine were also visited regularly by social mobilisers. The role of social mobilisers was to educate people in quarantine about EVD, how to prevent transmission and infection with EVD while in quarantine (and after), and to report suspected symptomatic cases.

A person was considered a suspected case if they met one or more of the following:

1. a person with fever and ≥ 3 of the following symptoms
   a. vomiting;
   b. headache;
   c. nausea;
   d. diarrhoea;
   e. difficulty breathing;
5.2 -

f. fatigue;
g. abdominal pain;
h. loss of appetite;
i. muscle or joint pain;
j. unexplained bleeding;
k. difficulty swallowing;
l. and hiccups;

2. a symptomatic person (see list above) who attended a funeral or cared for someone who was sick; and
3. an unexplained death (50).

A person was a confirmed case if they tested positive with a reverse-transcription polymerase chain reaction (RT-PCR) test specific for Ebola virus (50).

Cases in the cluster were summarised by age, gender, onset, outcome and risk factor. A disease transmission tree was developed to describe links between cases and the timeline of events.

**Results**

The ten year old boy who was a missing contact (case 2, Figure 7) triggered a transmission chain that lasted three months, spanned six villages (located in six separate chiefdoms) and two districts. In total (including the index case), there were 13 confirmed cases and two suspected cases (Figure 7). Of these 87% (n = 13) died. Twenty-seven percent (n = 4) were male and 73% (n = 11) were female. The median age of cases was 28 years (range: 11 days to 65 years). The date of onset ranged from 26 April 2015 to 10 July 2015. Of those who died, seven died in the community and six died in the ETU. Of those who died in the ETU, five were already in the later stages of the disease (phases two and three) by the time they were admitted to the ETU.

In the transmission chain stemming from the ten year old boy (case 2), a total of 294 contacts were identified. Of these, 73 were classified as high risk. Twelve high risk contacts developed laboratory confirmed EVD. Two high risk contacts were suspected
to have developed EVD, but this could not be confirmed because they had already been buried secretly before samples could be collected. No low risk contacts developed EVD.

Sixteen high risk contacts ran away before they could be quarantined. Of these, five were found and quarantined, four were found and taken straight to an ETU, one was found dead in the community, another was also found dead in the community after having died shortly after giving birth to a baby girl and five were never found. Of these five who were never found, four were reported to have fled to Guinea and are reported to still be alive, and the other fled to another district in Port Loko, but his final health status is not known.

Interventions consisted of quarantining high and low risk cases into separate quarantine homes, monitoring and educating contacts while in quarantine and immediate removal and transport of suspected symptomatic cases to an ETU for testing and treatment.

Within this cluster, risk factors for developing EVD were:

- washing and burying the dead body of an EVD case (53%, n = 8);
- sleeping in the same room or having close living contact with an EVD case (13%, n = 2);
- caring for a symptomatic EVD case (7%, n = 1);
- assisting with the labour of an EVD case without wearing appropriate personal protective equipment (13%, n = 2); and
- being born to an EVD case (7%, n = 1) or exposure to EVD positive breast milk (7%, n = 1).
Figure 7: Transmission tree showing confirmed and suspected cases of EVD, and their outcome, in Port Loko district for cluster X from 26 April 2015 to 11 July 2015
Discussion

This chapter describes the findings of the epidemiological investigations and interventions conducted in response to a cluster of EVD cases that occurred from 26 April 2015 to 10 July 2015 in two districts in Sierra Leone.

A higher proportion of women in this cluster developed EVD in comparison to men. This is inconsistent with the WHO reports which report that the total number of cumulative EVD cases has been similar in males and female (51). The higher proportion of females affected by EVD in this cluster might be explained by the females in this family taking on more of a role in caring for their sick family members, and by the fact that one of the key transmission events was the delivery of a baby, of which only women attended. These risk factors may vary in proportions within small clusters, but even out when the data are analysed overall for the whole West Africa outbreak.

The median age of EVD cases affected in this cluster is consistent with previous studies that have reported the median age of their cases to be 26 and 28 years (50, 52). It is also a likely to be a reflection of the young age of the population – people aged 15-35 years comprise one third of the Sierra Leonean population (42).

The case fatality rate for this cluster was high. The WHO reports the case fatality rate for the West African outbreak overall to be 50% (30). However, this is among hospitalised patients (53). Being admitted to an ETU is associated with a 50% reduction in death (54) and the chance of survival is also increased the earlier a case is admitted (55). Within this cluster, seven cases never made it to an ETU and of the six who did get admitted to an ETU, five were already in the later stages of EVD.

Fifteen high risk contacts ran away before they could be quarantined. Contacts fleeing to avoid quarantine or fleeing during quarantine has been one of the challenges for the overall outbreak response (56). Some of the reasons contacts are reported to flee include: mistrust of response efforts, limited understanding of EVD, community misperceptions, fear of ETUs, stigma associated with being a contact and being in quarantine, and financial and social pressures while in quarantine (56, 57).
Taking part in unsafe burial practices was the most common risk factor for developing EVD in this cluster. This is consistent with previous findings from this outbreak (50) and past outbreaks (58, 59). In November 2014, WHO in Sierra Leone estimated that 80% of cases were linked to unsafe burial practices (43). In Sierra Leone, some traditional burial practices include bathing or anointing others with the water that has been used to wash a corpse, and/or to sleep near the corpse for several nights (43). Because unsafe burials were identified as high risk practices, the Government of Sierra Leone mandated safe burial practices. However, strong cultural burial traditions made this a difficult intervention to enforce (43, 57).

The second highest risk factor for developing EVD in this cluster was sleeping in the same room or having close living contact with a case. This is consistent with risk factors reported previously in this West African outbreak (30, 50, 60), as well as in other EVD outbreaks (58, 59).

Assisting with the birth of an infant when the mother is EVD positive is a high risk event (61). A pregnant woman with EVD is contagious through the normal means of contact with blood, saliva, sweat, vomit, urine and faeces, but also to the infant and delivery assistants through the amniotic fluid (61). Assisting with the labour of an EVD case must be done wearing appropriate personal protective equipment to reduce the risk of disease transmission (61, 62). Two cases in this cluster did not wear appropriate personal protective equipment when assisting with a high risk birth from an EVD positive mother.

Very little is known about infants born to EVD positive mothers. Recent data have shown that in utero transmission of EVD from the mother to the foetus occurs (63). Previous studies have also reported suspected EVD in infants born to EVD mothers, all of which died within 19 days of being born to EVD positive mothers (60, 64), however the EVD status of the infants could not be confirmed with laboratory testing (60, 64). What is not clear in these studies and in this cluster, is whether the infants become infected in utero, during delivery, or through contact with other body fluids after delivery. Up until very recently, no infant born to an EVD positive mother had been known to survive beyond the neonatal period (61). However, the last reported case in
Guinea was an infant born to an EVD positive mother. She was born in an ETU, treated with experimental anti-viral medications and tested negative for EVD for the second time on 16 November 2015 (65).

The last case for this transmission chain was a 13 month old breastfeeding child. The source for this case is likely to be the EVD positive breast milk. Ebola virus has been detected in breast milk previously, however little is known about the infectivity of the breast milk (66), how long the breast milk remains infectious or when the virus appears (67). Further studies are needed to understand this risk factor for EVD.

This cluster investigation illustrated several of the many challenges that have persisted throughout the whole EVD outbreak response in West Africa: mistrust of response efforts, limited understanding of EVD, community misperceptions, and highly mobile populations (56, 57) (as evidenced in this cluster by contacts fleeing), and burials being conducted in secret. The WHO reports that the successful control of an EVD outbreak requires the following key interventions: safe burials, contact tracing, early identification of cases, rapid isolation, accessible and timely laboratory testing, and care for those infected (68). In this outbreak many of the aforementioned challenges hindered the implementation and success of these interventions. What is missing in this list that would address some of these challenges is a strong emphasis on community engagement. Community engagement should be embedded and intertwined throughout this list of the interventions. Community engagement that includes information and advice that is culturally appropriate so that people can make informed decisions to reduce the risk to themselves and others. This includes the engagement of trusted local leaders and even traditional healers. Seeking care from a traditional healer was banned in Sierra Leone (69) which led to sick people seeking care from these trusted healers in secret which drove silent or undetected transmission chains. Traditional healers should have been brought into the response, not excluded from it.

Engaging with communities and building up trust takes time – an element that is often a luxury in an outbreak setting - but at the same time could be one of the keys to its success. As stated by The United Nations ‘The outbreak in West Africa will end when we get to zero cases. To achieve this goal, communities must be at the heart of the
response. If people with Ebola are to come forward and transmission is to be interrupted, communities must be fully involved in, and owning, the outbreak’ (70).

In spite of these challenges, this cluster came to an end on 11 July 2015, along with the many other Sierra Leonean clusters. The country reached 42 days without a case on 7 November 2015, meaning it was able to be declared EVD free, and to date (29 November 2015) remains EVD transmission free (39).

**Conclusion**

This was a complex cluster driven by challenges that have persisted throughout this outbreak: fear, mistrust of response efforts, limited understanding of EVD, community misperceptions and a stronghold on cultural traditions. Despite being over a year into the outbreak, these challenges were still present. A stronger emphasis on community engagement might have reduced the risk of disease for some of the cases in this cluster. This investigation also shows the impact a missing contact can have in this outbreak setting and how essential it is to have a complete and accurate contact list to control an outbreak.
References


Appendix 1: Presentation to Indigenous Health Divisional Forum describing experiences from the field working as part of the response to the Ebola Virus Disease Outbreak in Sierra Leone, 28 October 2015

**Ebola outbreak in Sierra Leone - experiences from the field**

Anna-Jana Arnold
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**Outline**

- Overview of outbreak
- Overview of Ebola Virus Disease (EVD)
- How I got involved
- What I did
- Cluster investigation

**The Ebola Virus Disease (EVD) Outbreak in West Africa**

- First large Ebola outbreak in West Africa
- As of 18 October 2015:
  - 28,512 cases
  - 11,313 deaths

"The Ebola epidemic ravaging parts of West Africa is the most severe acute public health emergency seen in modern times. Never before in recorded history has a biosafety level four pathogen infected so many people so quickly, over such a broad geographical area, for so long" (WHO)
What is Ebola Virus Disease?

- Caused by the Ebola virus
- Symptoms:
  - Sudden onset of fever
  - Weakness, muscle pain, headache, sore throat
  - Vomiting, diarrhoea, rash,
  - Impaired kidney & liver function
  - Some cases have internal and external bleeding

What is Ebola virus disease?

- 2-21 day incubation period
- Contagious when symptomatic
- 25-50% case fatality rate (range 52% - 73%)
- Treatment includes supportive care – fluid replacement

Ebola origins and transmission

- Initial spread: From infected fruit bats to chimpanzees, gorillas, and other monkeys
- Current transmission: Person to person
- Virus contact with infected body fluids or dead body

So how did I get involved in this outbreak?

Sierra Leone
Chapter 5.2

Port Loko

- Situated in West Sierra Leone
  - Population: 300,000
- Main economic activities:
  - mining
  - Farming (rice, cassava, and sweet potato)
- English official language
  - Krio and Temne most widely spoken
- Hot spot for EVD
Chapter 5.2

What did I do?

- Epidemiological field investigations
  - Case finding and contact tracing
- Management of homes under quarantine
- Reporting

Photo of a home under quarantine.
Photo of a home under quarantine.
Presentation notes for cluster investigation slides (by slide number):

26: This circle represents a ten year old boy who had close contact with an Ebola case (his grandmother). He starts to feel unwell. His family start to fear for his life so they send him to a local herbalist.

27: The herbalist is not able to fix him so his other grandmother comes to collect him.

28: She takes him back to her family home to care for him where another 11 people live.

29: Sadly this 10 year old boy dies.

30: Shortly after, the grandmother also dies. Both bodies are washed and buried secretly. Traditional burial practices in Sierra Leone include washing and dressing the bodies of their dead loved ones. A practice that is both culturally very important for Sierra Leoneans but a practice that is also currently illegal in Sierra Leone because a body infected with EVD is at its most infectious when the person dies or just after.

31: The protocol at the moment is to call a number to arrange for the dead body to be buried in a safe way. This means that people that look like this come to the place where the person has died, decontaminate the body with chlorine, place the body in a doubled
up body bag and bury the body without allowing for the body to be washed or touched by loved ones. A practice that really clashes with local traditions, but needed from an outbreak control perspective. Unfortunately, this family did not do this, and this resulted in the disease spreading.

32: The next person to fall ill from the house was a 9 year old girl.

33: Followed by the head of the household.

34: For some reason the head of the household is the first one to reach out to the health system. He goes to the local public health unit. It’s at this first contact with the health system that we become alerted to this cluster. As soon as we become alerted, we are quick to go to the village where this case has come from to carry out our interviews to try to identify who is at risk and to find out who should be placed under quarantine to try to stop this cluster from spreading further. But we are not fast enough. On the same day that this man goes to the PHU, the worst possible thing from an outbreak perspective happens....

35: All of these people run away in different directions.

36: We manage to get 5 of them back but for 3 it’s too late. They are already showing late stage symptoms when they are found. They are taken to an ETU but sadly die shortly after.

Unfortunately, we don’t find this woman who is a pregnant woman close to term. She runs to her auntie’s house who is a traditional birth attendant, goes into labour and gives birth to a baby girl but dies shortly after, followed by her baby girl who dies 11 days later. Through the delivery and her travel to her auntie’s, she starts transmission chains 3 different villages.

These 3 men were never to be found during my time there. They were reported to have fled to Guinea. If they are alive, they have still not returned back to their home. It may be awhile before they do, because if they return home now, they run the risk of going to jail for being involved in secret burials.

I just wanted to highlight this complex cluster to you all because I think this cluster highlights the impact fear, misperceptions and a lack of trust and community engagement can have in this setting.
What really stood out for me from working on this outbreak was - I learnt that you can understand everything about the disease from a biological, medical, physiological perspective but if you don’t understand the people and have a way of communicating to the people in a way that speaks to them, and have interventions that are culturally appropriate, knowledge of the disease can becomes less useful.
Chapter 5.3 Appendix - Hepatitis A Case Control Study

I assisted with a multijurisdictional outbreak investigation into 19 cases of Hepatitis A that were suspected to be linked to the consumption of Brand A frozen mixed berries. A population-based case-control study was conducted to determine a statistical association between consumption of the product and recent infection with Hepatitis A. Controls were recruited with frequency matching (based on age group and Local Government Area) of two controls per case. Controls were sourced from state and territory notifiable disease databases, and were people with a previous history of infection with Salmonella species.

Selection criteria for controls were as follows:

1. notified to health departments in the two weeks prior to the onset date of the Hepatitis A case;
2. same age group as the case (0-4 years, 5-17 years, 18-49 years and 50 + years);
3. resides in the same Local Government Area or Health Region/District/Service as the Hepatitis A case; and
4. control (Salmonella case) is not part of an outbreak investigation.

Exclusion criteria for controls were as follows:

1. past infection with Hepatitis A or reports having had symptoms consistent with a diagnosis of Hepatitis A (i.e. Jaundice);
2. previous vaccination for Hepatitis A or have received Normal Human Immunoglobulin (NHIG) in the exposure period of interest;
3. those not contactable by telephone (mobile or landline);
4. those who are not English-speaking or unable to give coherent answers to questions;
5. those who travelled overseas during the two months prior to their notification date;
6. those who lived in a country/region with high or very high Hepatitis A endemicity for at least one year of the first five years of life; and
7. those who had close contact with a person known or suspected to have Hepatitis A during the study period of interest (2-7 week exposure period of corresponding case);

Eligible controls were randomly sorted into a list, and starting from the top, controls were selected into the study until two controls who met the selection criteria were interviewed for each case.

My role was to recruit and interview controls from Queensland to match Queensland cases, via telephone, and to enter their questionnaire data into NetEpi. NetEpi is an online password protected software used to enter and analyse data from epidemiological investigations (1). The questionnaire contained questions on eligibility, consent, demographics and structured questions on a limited range of fresh and frozen foods to assess potential exposures during the 5 week period prior to their illness.

As the controls were Salmonella cases, I also administered an extra questionnaire (to those who were interested) to collect information on their potential exposures in the five days leading up to the onset of their Salmonella illness in case they could be later linked to an outbreak.

I recruited and interviewed nine controls over a period of 3 ½ weeks. Of the 30 controls that I tried to recruit, one refused, five were ineligible, and 15 could not be reached. Prior to contacting the controls I contacted their general practitioner (GP) as a courtesy to advise them that I would be calling their patient to ask them to take part in the study, and to ensure that the patient had been advised of their Salmonella test results. I was not involved with the data analysis or interpretation of the results for this outbreak investigation, so it is therefore not discussed in this section.
Lessons learnt:

1. It is difficult to recruit controls and it takes time. Not including calls made to the GPs, I made a total of 68 calls over a period of 3 ½ weeks to recruit nine controls. The longer it takes to recruit the controls, the higher the chance the study will be affected by recall bias in participants. I think the time that it took to recruit the controls would have created a recall bias in this study.

2. Finding the best time to reach controls was difficult and variable. While calling out of hours resulted in a better response rate, it was not unusual to encounter a disgruntled person on the other end of the phone for having called them out of work hours.

3. I learnt the importance and challenge of reading out questions in a neutral manner and exactly as they are written. This is important to avoid or reduce interviewer (information) bias but this can also make it difficult to sound natural.

4. It is difficult to interview parents of young children who have undergone a serious illness. One parent in particular had gone through a very traumatic time with her son having been so ill as a result of his *Salmonella* infection, she thought she was going to lose her child. This was a very delicate conversation to have which has made me think that perhaps there should be a class taught to MAEs on how to speak appropriately to people who are emotionally charged and on how to build rapport. She requested additional information from the Queensland Department of Health regarding the species of *Salmonella* that had infected her son, and of any known outbreaks that had occurred at the same time her son became infected. I contacted the Queensland Department of Health regarding this control’s situation and her request for further information. The Queensland Department of Health responded quickly and I was able to go back to her with advice and the information she requested.

5. I learnt that there is a good structure and system in place with OzFoodNet on how to respond at a multijurisdictional level to foodborne outbreaks. This was interesting to observe particularly considering that the same systems were not
in place to manage the multijurisdictional investigation into the increase in *Ralstonia* cases that I investigated in the previous year. This system allows for a timely, well-coordinated multijurisdictional response.

6. It can be difficult to read your own handwriting! If data aren’t entered within a short timeframe after the telephone interview has taken place, this can lead to errors with data entry and potential non-differential misclassifications.

7. It can be difficult in some cases to apply the exclusion/inclusion criteria – for example, some of the controls could not remember if they had previously had the Hepatitis A vaccination prior to travel. This information had to be teased out by trying to find out if they had any vaccinations at all prior to travel. As a result of this, it is possible that people who had the Hepatitis A vaccination but could not remember and who said no, could have been erroneously included into the study and potentially have biased the results towards the null. In situations where participants were not sure, I excluded them from the study.

**Reference**